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The Origin Zero

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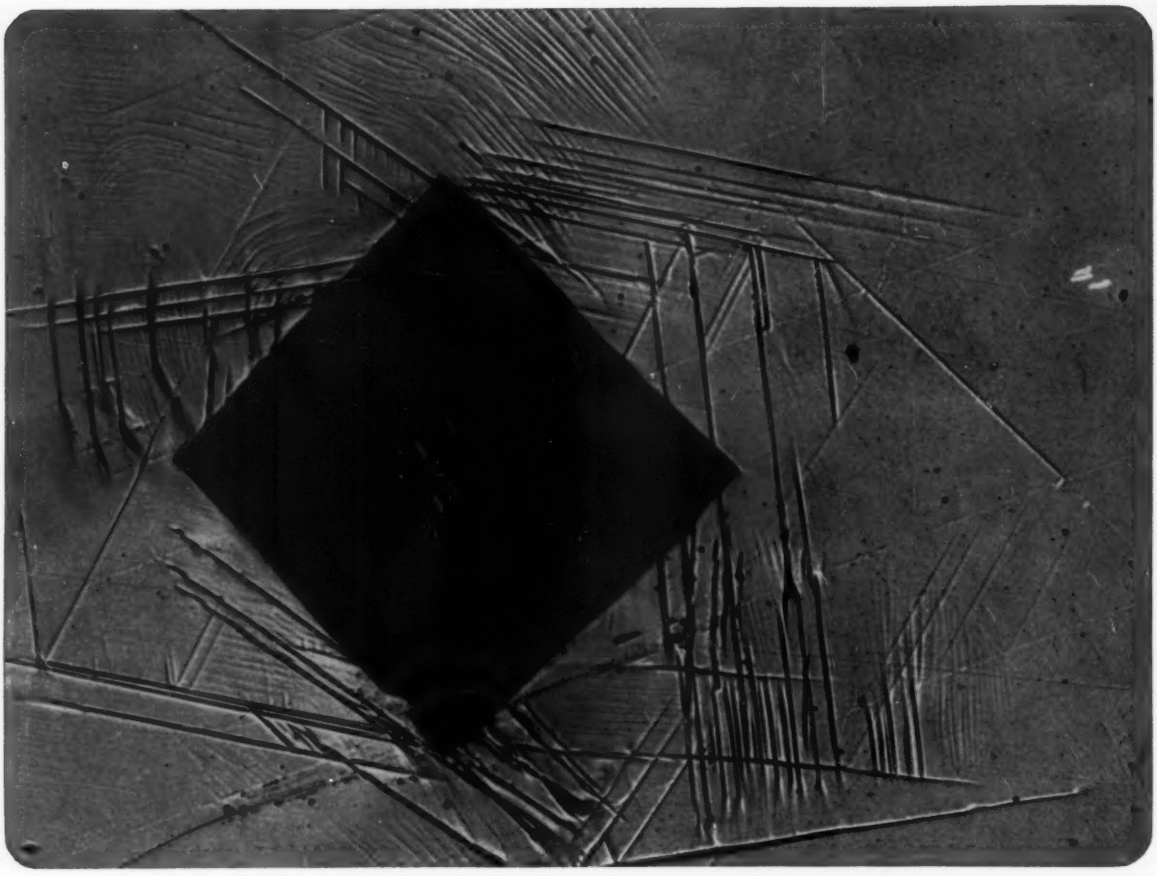

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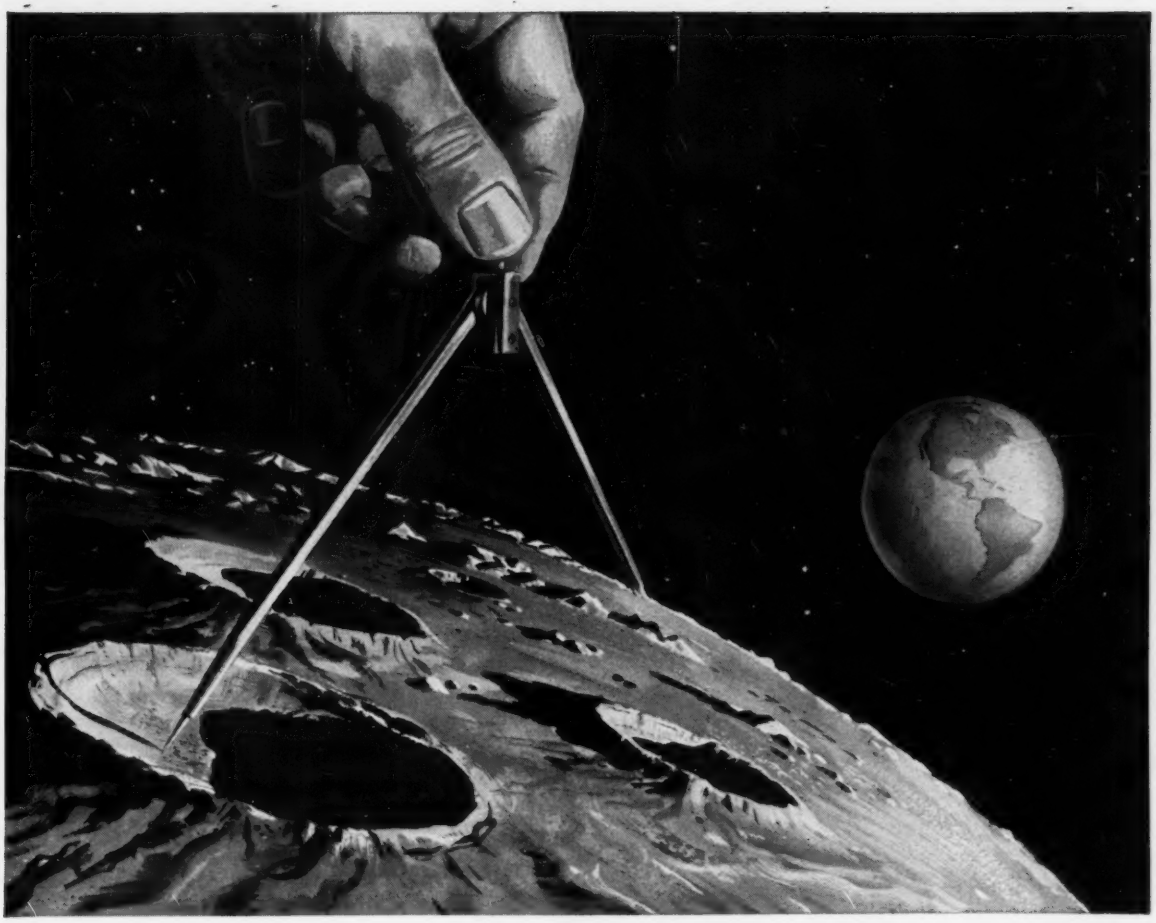

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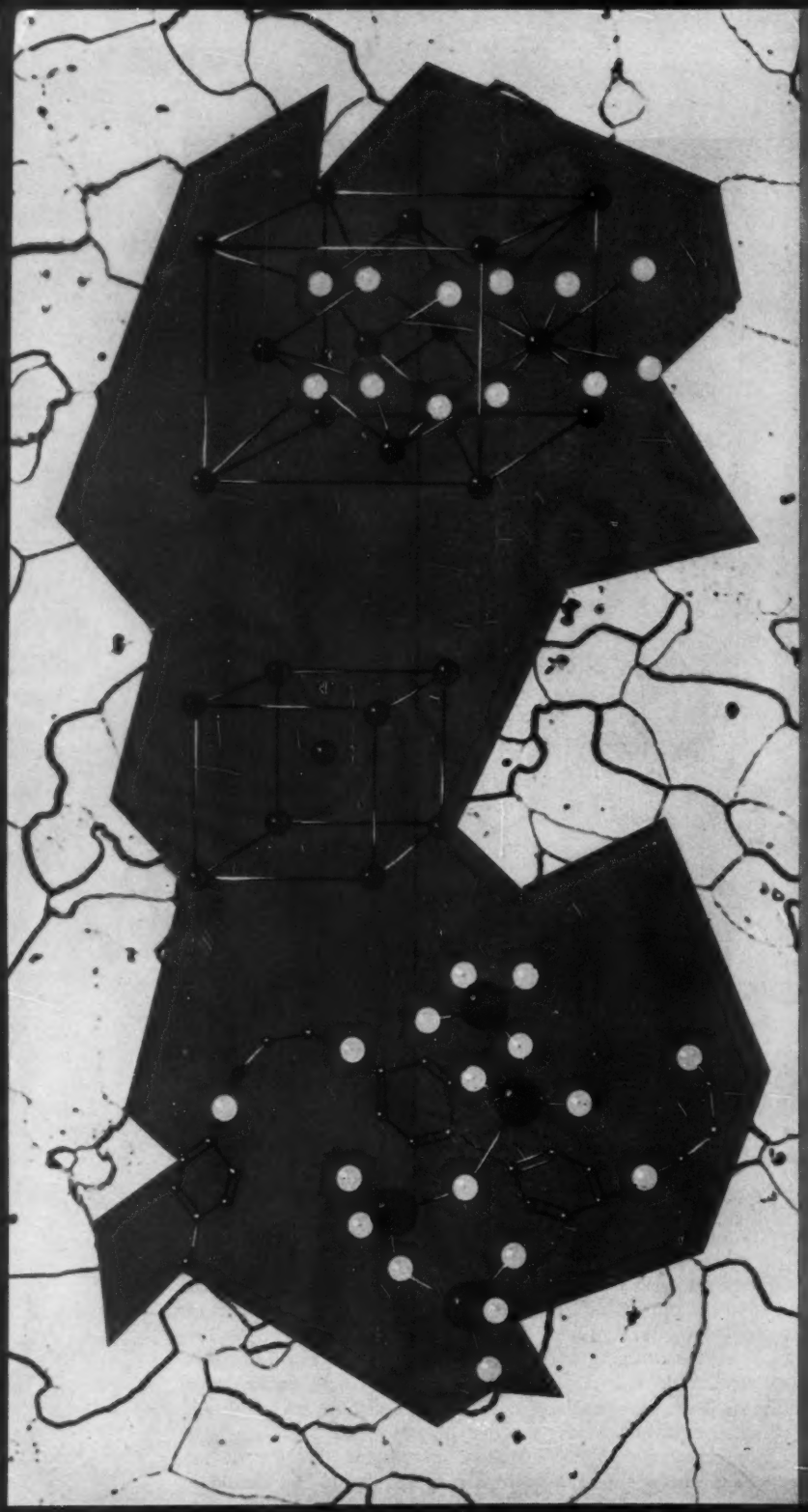

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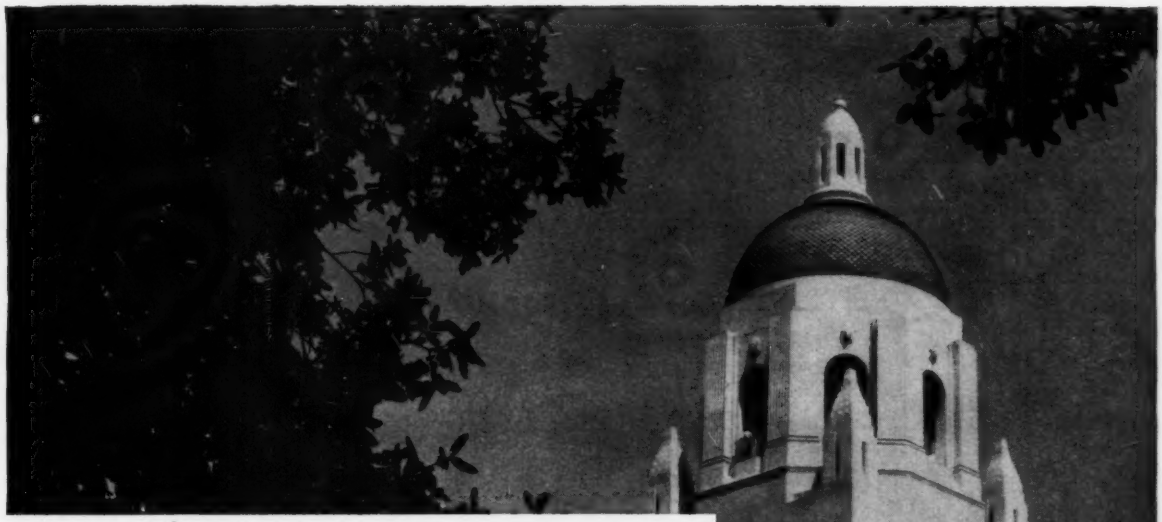

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For additional information, write Mr. R. C. Beverstock, College Relations Director, Lockheed Missile Systems Division, Sunnyvale , California.

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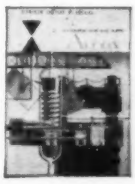

Herbert Spencer...on the genesis of science

"Without further argument it will, we think, be admitted that the sciences are none of them separately evolved — are none of them independent either logically or historically; but that all of them have, in a greater or less degree, required aid and reciprocated it. Indeed, it needs but to throw aside hypotheses, and contemplate the mixed character of surrounding phenomena, to see at once that these notions of division and succession in the kinds of knowledge are simply scientific fictions: good, if regarded merely as aids to study; bad, if regarded as representing realities in Nature. No facts whatever are presented to our senses uncombined with other facts — no facts whatever but are in some degree disguised by accompanying facts: disguised in such a manner that all must be partially understood before any one can be understood."

—The Genesis of Science, 1854

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Then, in September 1957, Art was transferred to the Coupling Sales Department as a Coupling Application Engineer. He is serving in that capacity now.

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Art is particularly articulate about his job and the constant challenge it presents for him as an individual.

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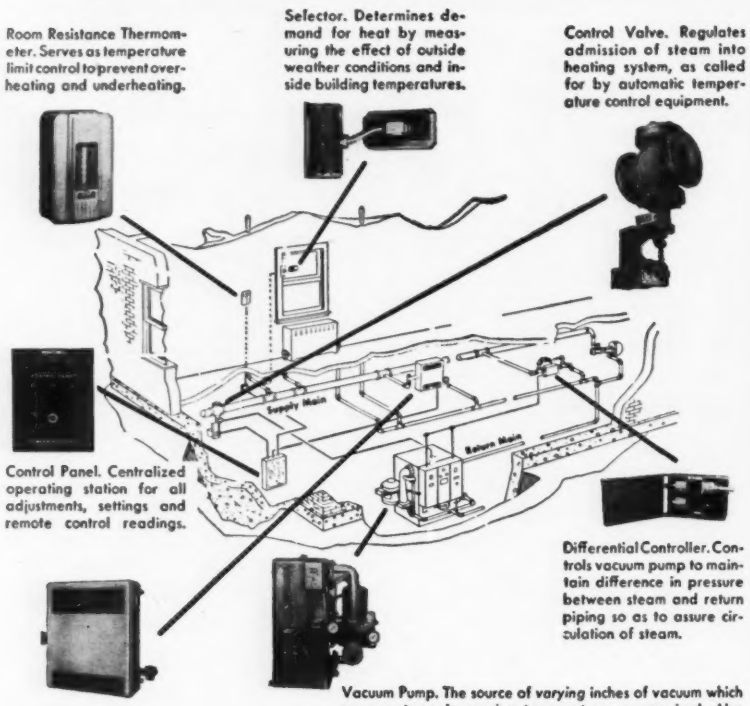

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STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

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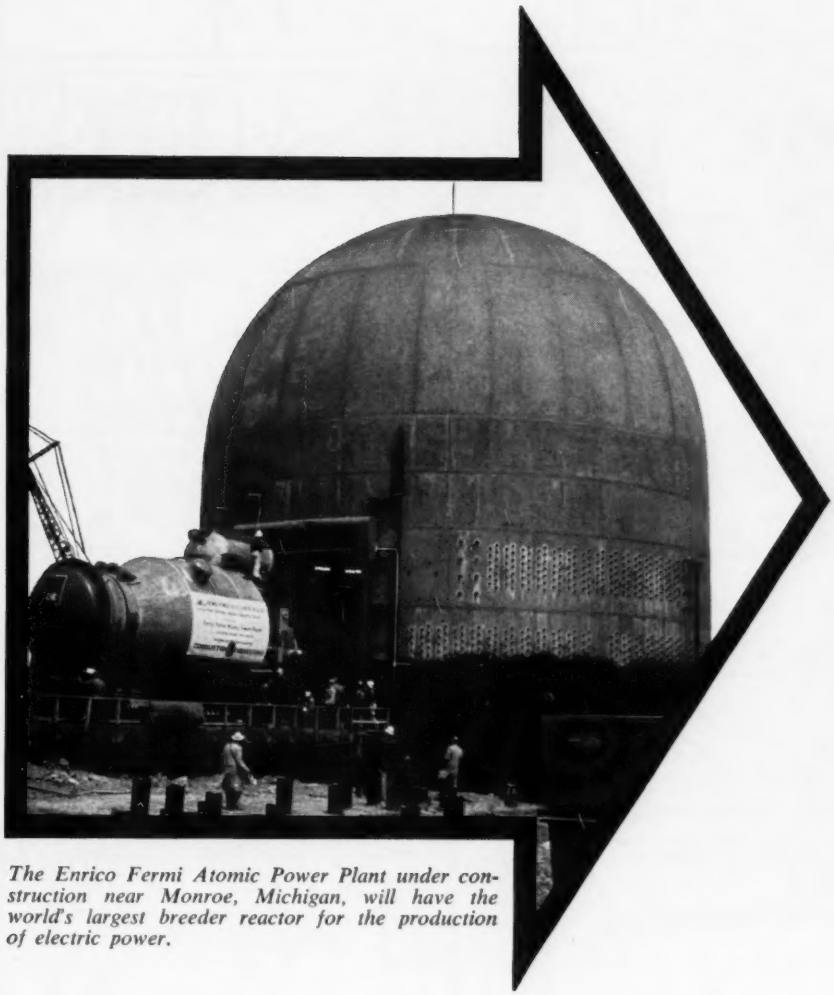
Into the atomic era of new engineering opportunities



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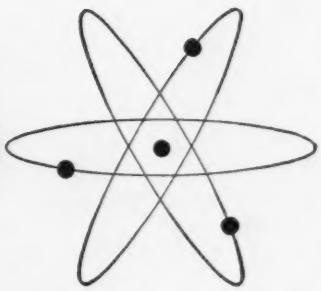

To the young engineers of America's electric power systems, the hope and promise of the peaceful atom grows clearer day by day. In laboratories and on construction projects these young men are serving our nation's new atomic-electric power industry.

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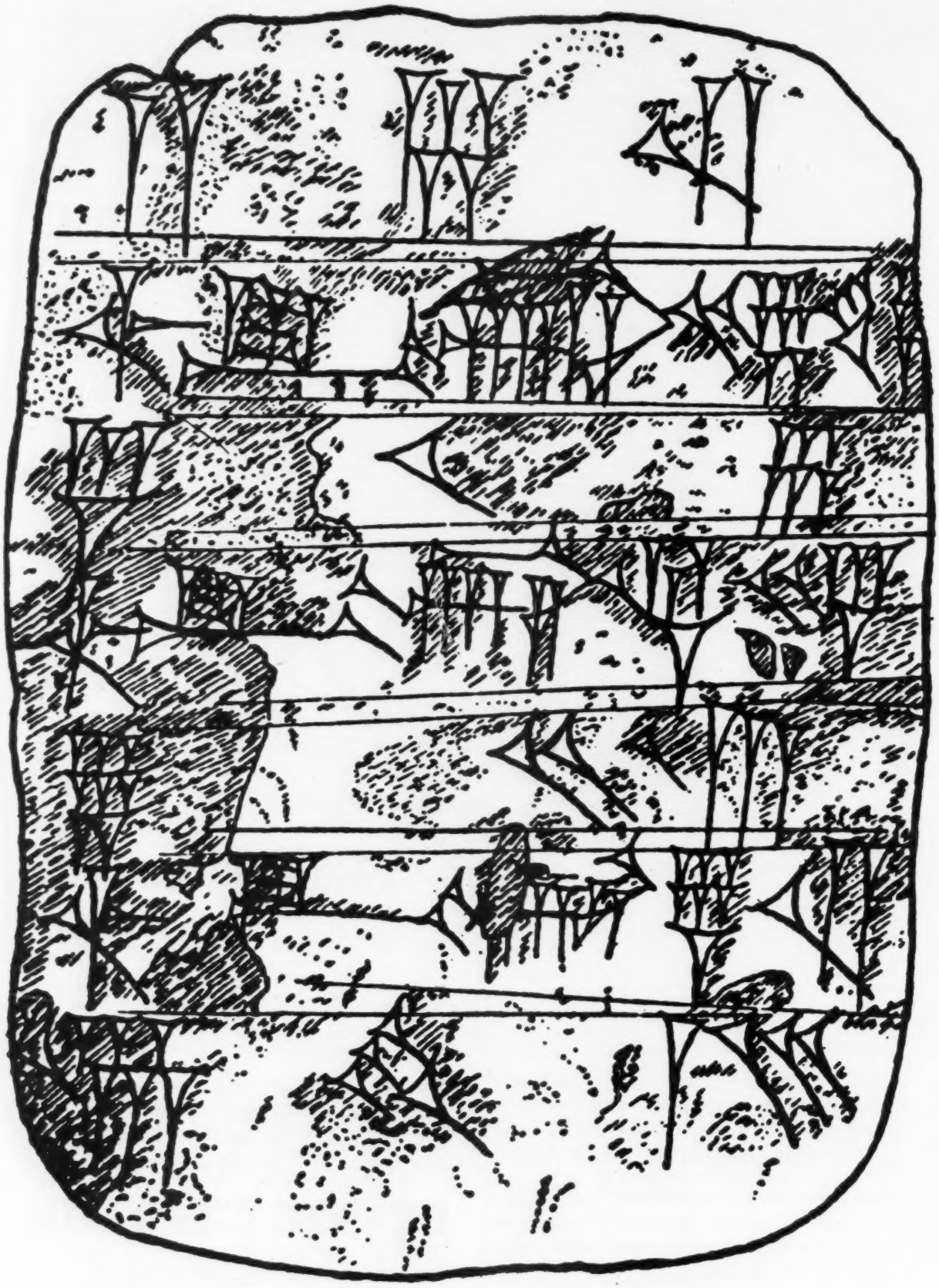


THE ORIGIN OF ZERO

by
David L. Ripps, ChemE '59

The degree to which the concepts of mathematics are developed in a primitive culture depends upon the needs, attitudes and ingenuity of the people. The primary cognition of separateness or distinctness is basic not only to the conception of numbers, but also for all forms of languages and social communication. Just as important is the ability to group distinct things: to find some common characteristic which mentally binds otherwise dissimilar units. A further development for the primitive mind is the discovery that it is sometimes possible to exactly, but arbitrarily, pair off the members of one group with those of another so that a one-to-one relation exists between the members of the two groups.

The concept of cardinal number finally is the recognition of the common property shared by all groups having a one-to-one relation with a single group. (For instance "three" is the cardinal number of all triads, all groups having a one-to-one relation with the collection: • • •.) As soon as the relationship "greater than" or "less than" was applied to the cardinal numbers they became, as well, the ordinal numbers used in counting.

In unconsciously deriving these primary notions of number, early man used commonplace things in groups no larger than could be conceived of in his primitive mind. Thus the earliest numbers were the first few positive integers and a word for a large number or "heap."

Generally the more subtle concept of a null class or memberless group with cardinal number zero is not needed and does not develop at this time. As food gatherers and hunters become settled farmers and traders, a practical need for fractions and large numbers may be met by the direct continuation of previous notions with new words or symbols created for the new numbers. If skill is high, however, the more efficient place-value system of enumeration with a zero may develop. Exact details of this arithmetic expansion and the emergence of a zero are a matter of specific cultural history.

Crude Zero Developed

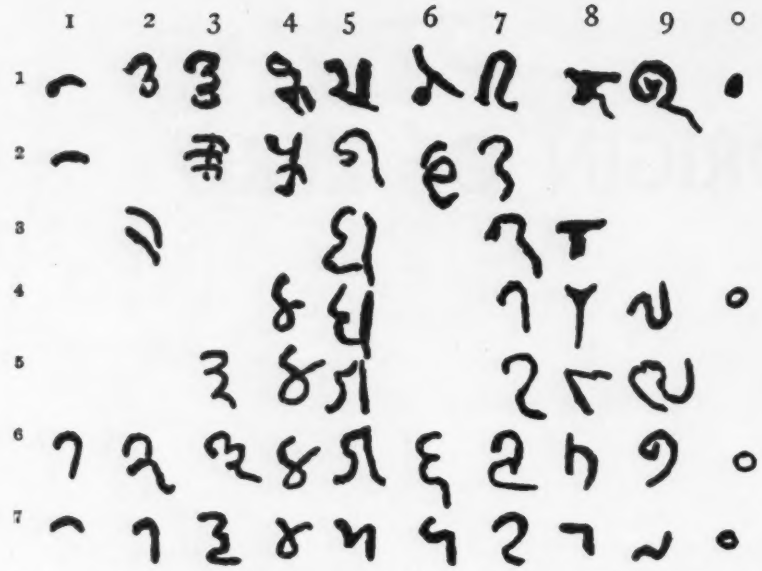
The earliest recorded use of a mathematical zero is found in ancient Mesopotamia in the cuneiform tablets of the late Seleucid Period about 300 BC. Centuries before, the sixty-to-one ratio common in weights and agricultural measures because of its convenient divisibility had been generally adopted to all numeration. Thus, sixty units of one kind was written as "1" of the next higher order. At first bigger symbols were used to represent the higher units, but as script slowly became standardized and simplified, the distinction between large and small disappeared with the system of "size-value" giving way to a more convenient one of "place-value." Zero was not included in the system at this time. To simplify the handling of common fractions by eliminating special rules for their handling, the Sumerians used both positive and negative powers of the sixty base. In this way, ½ (30/60) would be written simply as 30, and treated exactly like that integer.

Although this sexagesimal notation is profoundly better than most others developed in the ancient world, its lack of a zero introduced ambiguity in two ways. First, there was no uniform procedure for indicating the complete absence of a sexagesimal order or digit, although a wide space was used by some scribes. Thus the notation 1 15 would be used to represent both $1 \times 60 + 15 = 75$ and $1 \times 60 + 0 + 15/60 = 60.25$. Furthermore, the order of magnitude of the number, although generally known by context, was not specifically designated. Both a given number and any multiple of sixty times that number had the exact same designation.

Some of the first-mentioned confusion was gradually eliminated late in Babylonian history (c. 300 BC) when a definite punctuation mark was inserted to mark the absence of a digit. In only the crudest sense, however, was this symbol a

←

An early Babylonian tablet, dating back to about 2400 B.C. contains divisors of 60^4. The quotients are in geometric progression. The top line reads 2(•60), 5(•60), and 12(•60).



The various forms of the numerals used in India after the zero or sunya appeared may be judged from the table shown here. The form of the zero may have been suggested by the Hindu use of a small circle or dot to indicate a negative, or something "long since forgotten."

zero since it was neither considered a true number, nor used in arithmetic by itself. Since it was uncommon to place zeros at the ends of a number, the confusion as to absolute magnitudes was never totally resolved.

Hindus Grasp Concept of Zero

The first people to understand the full significance of zero as a number were the Hindus of the fifth or sixth century. From earliest known times, ten has been the basis of Indian numeration, probably to commemorate prehistoric finger counting. In ancient Sanskrit, literature numbers were generally written out using the system employed in our literature for large numbers. For example: 1,234 would be written as 1-thousand, 2-hundred, 3-tens plus 4-units. Words for the nine numerals, and a long series of denominations (in powers of ten from one to ten-billion) permitted extremely large numbers to be conveniently described. The Hindus wrote out their calculations in sand or red flour strewn on wooden tablets. They also used a thin erasable paint. The nine digits were represented by symbols.

At first, undoubtedly the Indian counting board or abacus was divided into columns for successive orders of the base (ten) according to the universal custom. It is no longer possible to determine when the symbol for the blank or void column was introduced, and when the lines were dropped to give a true place-value notation. Probably by about the first century B.C., the various column positions had become associated with the corresponding literal denominations, and the new decimals began replacing various other systems in use at the time.

The first undoubted epigraphical instance of the new system complete with its zero was in 594 A.D., although literary references go back about another hundred years. Thus, the early development of the Hindu decimal system in principle paralleled that of its Sumerian predecessor. A zeroless, place-value notation was reformed by the insertion of a small circle or dot (sunya) to denote the absence of a figure, and to fix the absolute value or decimal place of the number. Sunya was not considered a mere blank space marker, however. It was ranked a numeral and treated in arithmetic as any true number would be treated. In fact, all early Hindu mathematical treatises have a section devoted to zero in which the results of all arithmetic operations with zero—except its division into a finite quantity—are stated correctly.

At first the standard definition of zero was the sum of two equal and opposite quantities: nothing or sunya. But this definition bothered thoughtful Hindus—how can sunya be used in arithmetic or algebra when all their operations imply the existance of the quantities concerned? To finally resolve this dilemna, zero had to be a "quantity in the utmost degree small"; a quantity so small its value was almost, but not quite, nothing. To justify such thought, Ganesá (1545) proposed, "The utmost diminution of a quantity is the same with the reduction of it to nothing." Conceived thus as an infinitesimal, zero could be considered a true number justified in its algebraic operations.

Babylonians Fail to Get True Zero

In comparison with the Hindus, the Babylonians failed to progress in their mathematics after a startlingly early gain of an efficient place-value system of notation. They apparently stagnated just short of a full understanding of the integer zero and without negative numbers. The limitation of their concept of zero, however, was inevitable because of the extremely practical nature of the Babylonian people and their completely empirical approach to technology. Mathematical progress was stimulated by the needs of agricultural astronomy, engineering, and commerce, and not by the desire for intellectual fulfillment, the exercise of creativity for its own sake, or the satisfaction of a basic curiosity of nature.

The basis of the Sumerian civilization which founded Babylonian arithmetic (3500 to 2500 B.C.) was agriculture, the success of which depended upon a reliable calendar to record and predict the planting season. The calendar in turn, required an accurate arithmetic astronomy which was founded on an empirical basis. Extensive primitive irrigation and other large construction projects further stimulated empirical calculations, although jobs were more often completed by the sheer mass of the labor force than by the efficiency of computational planning.

Furthermore, Babylonia was in an exceedingly advantageous commercial position directly across the path of merchants at the northern end of the Persian Gulf. An ex-

traordinarily large number of economic tablets show that the Sumerian merchants of 2500 B.C. were already familiar with weights and measures, bills and accounts, and usury—both simple and compound.

Sumerian mathematics, rooted thus in an agricultural astronomy and nourished by the needs of an aggressive commerce and ambitious primitive engineering, flowered as a purely applied arithmetic algebra. Aided by an effective place-value number system, the Sumerians far excelled in the matter of practical calculations.

Although the Babylonians were extremely weak in geometry, they were able to divide farm land bounded by several straight lines by resolving the problem into a set of verbal, linear, simultaneous equations. With their clumsy but accurate nonsymbolic algebra these equations—sometimes ten in number—were successfully solved. Engineering calculations at times produced verbal quadratic and even cubic equations which were correctly solved with heavy reliance upon reciprocal, product, square root and other elaborate tables. Interpolation from initial trial successfully solved the exponential equations of compound interest, again with the aid of various numerical tables.

Since problems such as these often had long and detailed numerical solutions, internal ambiguity in the number system could lead to disastrous error in the final result. Thus the "blank-mark" concept of zero became indispensable. Zeros were generally omitted at the ends of a number. Any confusion about its absolute magnitude was accepted as the penalty for freedom to multiply and divide mixed integers and fractions with unusual ease. Since there was no symbolic algebra for equating to zero, often a powerful simplification, there was no practical need for the integer zero.

Furthermore, when technological empiricism completely dominated, there was no systematic or theoretical study of numbers which could have led to the discovery of zero by purely intellectual means. In fact, the numerical solutions of specific problems preserved on cuneiform tablets never even indicate the thought process inspiring the methods used. Never is a pattern isolated as a general procedure, or a formula set out in words or symbols—although the knowledge of both general procedures and formulas is clearly indicated by the nature of the solution. Proof was never offered, nor was it ever indicated why the particular methods employed resulted in a correct solution.

It has been suggested that Babylonian mathematics was a jealously guarded secret of a priestly sect. If there were conducted behind closed temple doors any extensive systematic study of the primary concepts of mathematics, in complete contrast to the empirical techniques used elsewhere in Sumeria, it must have failed. Such critical analysis assuredly would have led the Sumerians, as it did the Hindus, to the practical innovation of a symbolic algebra with a zero and negative numbers.

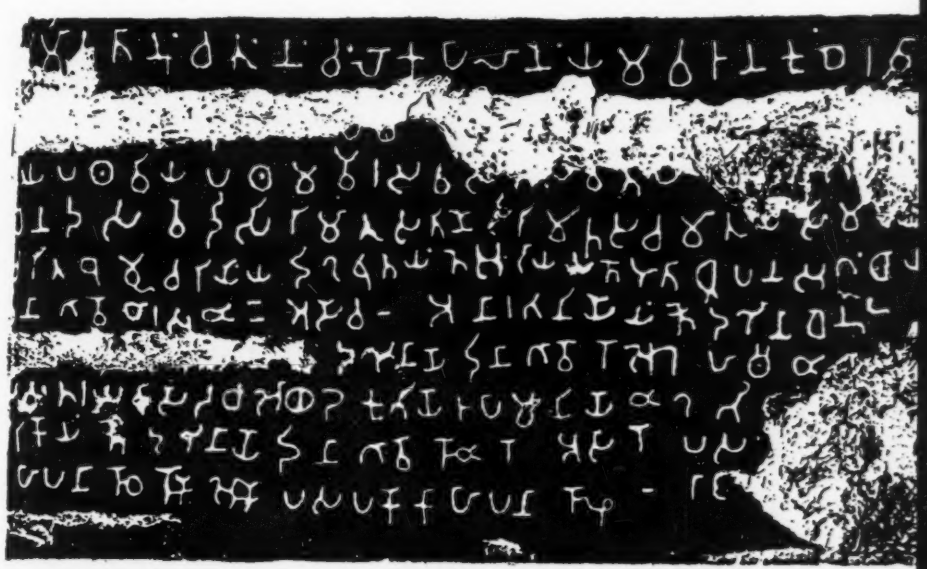
Intellectual Inquiry Spurs Hindus

Althought both the Hindus and Sumerians achieved a highly organized society surprisingly early in history—the Hindus having built brick houses in planned cities and used such metals as gold, silver, copper, and bronze as early as 3000 BC—the essence of the two cultures was radically different.

In Sumeria, as has been stated, technology existed almost entirely as a practical aid to the thriving commercial-agricultural economy. Economic practicality and empiricism dominated the popular philosophy. On the other hand, religion was the prime avocation of the Hindus. It dominated their entire culture. Early religious works, however, were only partly ritualistic, containing, as well, a highly developed system of metaphysical and social philosophy, and the seeds of most of the sciences and arts of modern civilization.

Although the mathematics of India originated with the primary object of helping the early Vedic religious rituals (c. 2000 BC), much as Sumerian arithmetic was the handmaiden of agricultural astronomy, in the course of time it outgrew its original purpose and was cultivated for its own sake. Even then, the appreciation of *ganita* (mathematics), as of any other branch of secular knowledge—science, art, philosophy—was not considered a hindrance to spiritual knowledge. In fact, religious literature considered arithmetic the first and noblest of the arts and a helpful adjunct of Para-vidya—the spiritual knowledge.

(Continued on Page 49)



One of the early records of Hindu Mathematics are the Nana Ghat Inscriptions found written on the walls of a cave about seventy-five miles from the city of Poona. A portion of the inscriptions are shown here. These inscriptions, made in the second century B.C., indicate the early intellectual interest the Hindus expressed in mathematics.

KEEPING THE MISSILES FROM MISSING

by

Richard A. Wolf, EP '62

The idea of an automatic guidance system was conceived in 1925 when someone suggested that a rocket might be guided by a strong beam of light and a photoelectric cell. The field has, of course, expanded greatly since then, and the development of guidance systems has become extremely important to our national defense.

There are at present two basic types of guidance systems, those which depend on man-made effects such as radar, sound, and radio waves broadcast from the ground, and those which depend only on natural phenomena. Considering first the systems involving man-made phenomena, the most obvious way to guide a missile would be to have it ride a beam of some nature from takeoff to destination. This beam could conceivably be made of almost any type of radiation, but it happens that radio waves furnish the only practical means of guidance.

Usually, the radio waves are sent out in such a way that the points of greatest intensity are on the outer surfaces of a cone-shaped beam. Thus if a receiver were placed in the tail of the rocket, it could tell by the intensity of the received waves where it was in relation to its prescribed path. This type of system is very practical for surface-to-air and air-to-air missiles, since observers on the ground, knowing the position of both the missile and its target, can control the beam so that the missile will contact its target.

A brain located in the missile could also track down a target automatically using a radar system to sense the position of the target. This type of system has one great disadvantage, however, which renders it unsatisfactory for long range surface-to-surface missiles. The missile can be made completely harmless if the enemy discovers it in time to jam its radio control system. However, these radio-controlled missiles will con-

tinue to be used for hitting moving targets.

Celestial Navigation

There are two types of guidance systems utilizing only natural phenomena in determining the position of the vehicle. The simpler of the two is celestial navigation. Two pieces of information are necessary, the angular elevation of certain stars above the horizontal and the time. Using this information, trigonometric computers can determine the position of the missile. However, this method has distinct disadvantages. It is rather difficult to design instruments which will accurately determine the true horizontal in a vehicle which is constantly accelerating, turning, pitching, and rolling. The methods used to determine the horizontal in nautical celestial measurements—bubble levels and sighting over the horizon—are not satisfactory for missile use. If celestial navigation is to be successful in missiles, a more complicated method for determining the horizontal will have to be used. Such a system is discussed in regard to inertial navigation.

The final solution of guidance problems is undoubtedly a completely self-contained unit which will need no stimuli from the outside after the missile is launched. An inertial guidance unit works in this way.

Sperry Gyroscope Co.

Special high precision indexing platform is used to measure accuracy of the integrating accelerometer. Master table automatically compares response in any position with correct answers. It is exact within plus or minus 1.5 seconds of arc.

A Fixed Reference System

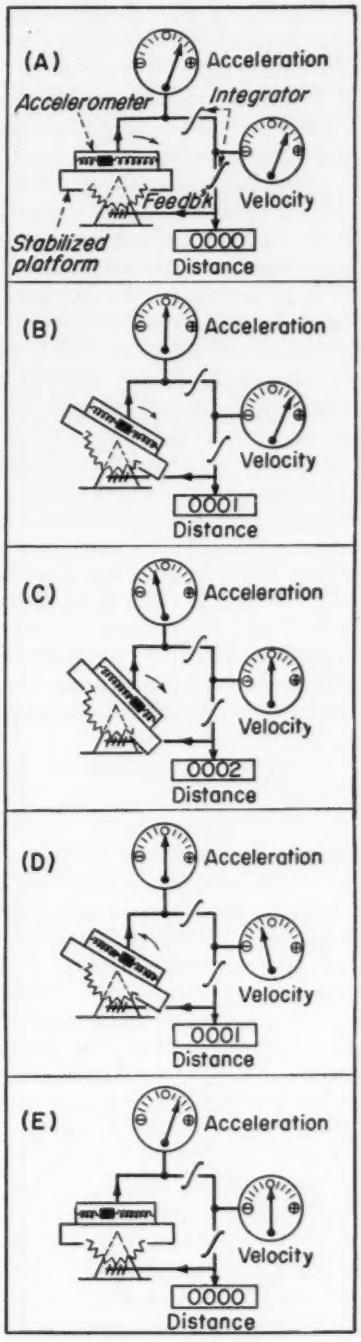
The basic problem in the inertial guidance system is to find the direction of the vertical to the missile's position and relate it to a fixed frame of reference.

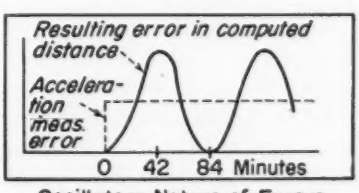
First consider the problems involved in determining this reference system. The most convenient fixed reference system for a missile is the direction of the vertical at the point of launching. The object is to have some instrument in the missile stay parallel to the vertical at the take-off point no matter what direction the missile moves. The most effective instrument for this purpose is the simple gyroscope. Its axis is oriented parallel to the vertical at the takeoff point and its rotor is kept spinning. It is allowed to swing freely in one plane so that each gyroscope will give the direction of the vertical in one plane.

The Schuler Pendulum

Having determined our fixed reference system, we now turn to the more complicated problem of determining the true vertical at the missile's position. One might at first think that a simple pendulum would be sufficient, since a pendulum normally points to the center of the earth. However, this is only true when the pendulum is not being acted upon by any forces parallel to the surface of the earth. If the free end of the string of a pendulum is accelerated, the string must transmit a force parallel to the surface of the earth to accelerate the bob. This means that the string cannot possibly stay vertical when its free end is accelerated. In a missile there are tremendous accelerations, and a pendulum mounted in such a vehicle would not indicate the vertical but would merely swing wildly.

However, it is not hard to visualize the fact that, if a pendulum were as long as the radius of the earth, and a large hole were drilled to the center of the earth so that the bob could stay at the center, the string would stay vertical no matter how much the free end was accelerated. The period of a pendulum of this length on the surface of the earth is 84 minutes. Dr. Maximillian Schuler, a German professor of applied mechanics, cal-





Oscillatory Nature of Errors

Aviation Week Magazine

The accelerometer is mounted on a stabilized platform, the angle of which is corrected by doubly integrated accelerometer readings.

culated that if some device similar to a pendulum could be constructed also having a period of 84 minutes, it would always indicate the true vertical no matter how much its free end was accelerated.

Naturally, a pendulum 3,963 miles long would be a bit impractical in a missile. However, a system has been devised whereby such a pendulum may be simulated. It makes use of a device called an accelerometer, which, in its simplest form, may be represented as a mass on the end of a spring. The acceleration to which the mass is subjected through the spring can be determined by measuring the elongation or compression of the spring. If this sort of device is put in a moving vehicle, and the signals from it are integrated once, the vehicle's velocity is determined. If the signals are integrated twice, the distance the vehicle has traveled can be determined.

In a missile, the position of the vertical changes relative to the fixed reference frame because the missile is going around a spherical body. However, the accelerometers which are to measure acceleration in the east-west and north-south directions must be kept exactly perpendicular to the vertical. Otherwise, an unwanted component of the acceleration of gravity affects their readings. In an inertial guidance unit, the accelerometers are usually mounted on a stabilized platform which holds a gyroscope to resist random turning motions. The platform itself is rotated by a system controlled by the double integrated signals from the accelerometers. Any time these signals indicate a significant change in the missile's position, motors rotate the stabilized platform so that the platform is again at the local horizontal. In this way, the stabilized platform is guaranteed to be very nearly horizontal all of the time. The direction of the true vertical, which was what we started out to find, is simply a perpendicular to the plane of the stabilized platform. If the angle between this perpendicular and the axis of the fixed reference gyroscope is measured, the position of the missile relative to its takeoff point is easily determined.

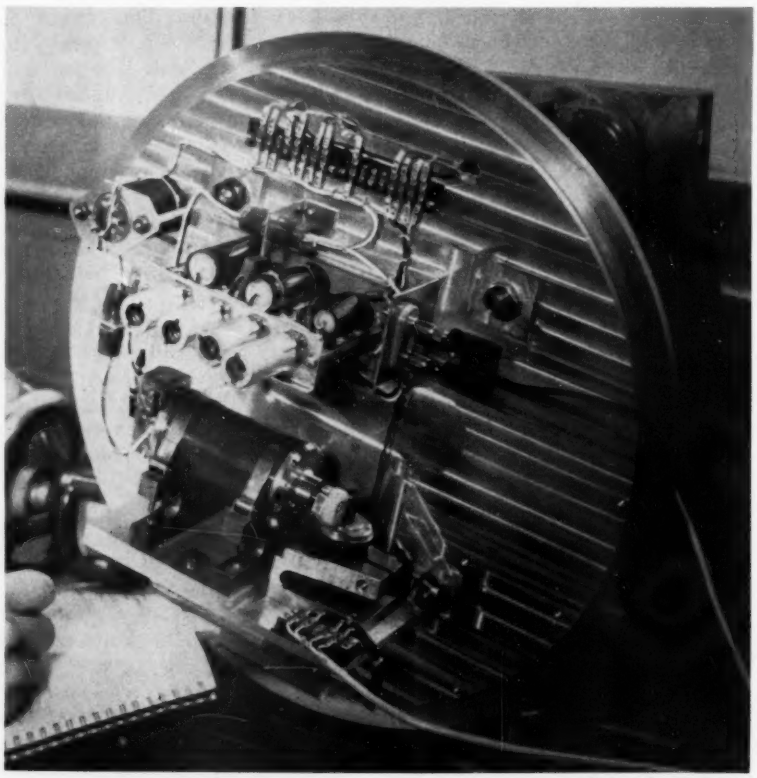
One will notice it was stated that the stabilized platform is guaranteed to be very nearly horizontal all of the time. However, there is a definite predictable error involved. Let us assume that our missile is cruising along. The double integrated accelerometer signals indicate a significant change in position. After a short reaction time, the motors start to turn the stabilized platform toward the new horizontal for that position. However, during the time it takes for the motors to react and turn the platform, the platform is a little bit away from the horizontal and a small component of gravity enters the accelerometer readings, making them a little bit too high. This means that once it gets going, the platform will rotate a little too far. When it does this, a component of gravity will enter the accelerometer readings again from the opposite direction, making them too low. The platform will start to swing back the other way. Thus, a simple harmonic motion of very small amplitude is set up in the system. The period of this motion is 84 minutes.

Two other minor accessories are necessary for the functioning of the unit. A clock must provide signals upon which a correction for the earth's rotation is based. These correction signals are added to the angle difference between the two verticals and the latitude and longitude of the takeoff point. The latitude and longitude of the missile's position are now determined.

It is also usually desirable to know the altitude of the vehicle. This can be determined simply from the doubly integrated readings of an accelerometer mounted vertically on the stabilized platform.

Design Problems

Although these operations may seem rather complicated, the principles behind them are much less complex than the design and manu-



Sperry Gyroscope Co.

This new integrating accelerometer employs a small cylinder of spinning liquid silicon instead of bearings to avoid errors due to friction and thereby obtain extremely accurate readings.

facturing problems involved in the production of the units. The integrators, gyroscopes, and accelerometers must be extremely accurate. Designing accelerometers poses an especially difficult design problem. The accuracy demanded of them can be illustrated in the following example.

Let us say that we are firing a missile from the east coast due east toward city "X", 5000 miles away. The acceleration of the missile during the journey might well reach 100 feet per second per second. But let us imagine that the east-west accelerometer in the guidance system was indicating a slightly lower value than it should have been, say .01 feet per second per second lower. The missile would zoom over city "X" and land in a field fifty miles or so east of town. Notice that an error of only one ten-thousandth of the accelerometer's maximum reading was sufficient to destroy the effectiveness of the hypothetical missile completely.

The principle of the linear accelerometer with spring and mass has already been explained. It is rather obvious that no such system could register accurately accelerations to one part in ten or one hundred thousand. Therefore, designers have been searching for new types of accelerometers.

One interesting accelerometer design is the electric spring accelerometer developed by American Bosch Arma Corporation. It is capable of measuring accelerations as small as .000005 g. A mass is attached to the outside case of a d-c motor. The motor case is supported between two low-friction bearings along the same axis as the armature. When the unit is accelerated so as to force the mass backwards and rotate the motor case, the armature of the motor spins in the opposite way. Thus an opposing torque is set up. The speed of the armature is increased until the torque it causes on the case just balances the torque caused by the accelerational force on the mass. The acceleration to which the unit is subjected can then be determined by checking the speed of the armature.

There are several other interesting types of integrating accelerometers. One is a system by which the frequency of a resonating device is regulated by the acceleration of the missile, and the velocity of the missile can be determined by counting the number of cycles the resonating device has gone through.

Another type of integrating accelerometer is the unbalanced gyroscope. The system is arranged so that an acceleration produces a torque on the gyroscope and causes the gyroscope to precess. The rate of precession is proportional to the torque. Measuring the total angular displacement of the gyro at any time determines the velocity at that time.

One of the most promising integrating accelerometer designs is one recently developed by Sperry Gyroscope. A small cylinder is immersed in a silicone fluid inside a larger cylinder. The large cylinder rotates at about 1000 rpm. so that the small cylinder stays exactly centered in the large one, due to the hydrostatic forces of the fast-moving liquid. The small cylinder is sensitive to accelerations along its longitudinal axis. The advantage of this arrangement is that there is essentially no unpredictable friction in the motion of the small cylinder. As the cylinder moves back and forth with the acceleration. By-pass tubes then move the fluid from one end of the large cylinder to the other. In this system, the velocity of the piston is exactly proportional to the acceleration and the distance the piston travels is therefore proportional to the velocity of the missile.

Manufacturing Difficulties

The accuracy required of all components of an inertial guidance system makes their manufacture as difficult as their design. For instance, at Sperry Gyroscope, one of the leading manufacturers of inertial guidance components, a new process has been added to the manufacturing procedures which consists of an electropolishing operation and an ultrasonic cleaning for all parts. Deburring and polishing of smaller parts is done with dental tools and a microscope. Dust cannot be tolerated on the surfaces of these components and a complex air filtration system is necessary to remove essentially all dust particles larger than twelve millionths of an inch in diameter. The temperature in all of the assembly rooms must be held to one or two degree tolerances. Humidity must be kept within 5 percent of 40 per cent.

The strict control of atmospheric conditions causes odd problems in the movements of personnel. To enter an assembly room, a worker first puts on a cotton undersuit supplied by the company. He then washes hands and face carefully and vacuum cleans his shoes. Next he enters a wind tunnel for a 30 mile per hour wind dusting. He then puts on dustfree, lintfree nylon coveralls, booties, and a surgical cap and goes back to the wind tunnel for another dusting. All of these precautions are necessary because a speck of dust in one of the delicate inertial guidance components could make it useless.

Future of Inertial Guidance

At present, the future of inertial guidance is still in question. Inertial systems are probably being used in most of our ballistic missiles, but we are still having great difficulty in making these missiles land where they were aimed. Because of the difficulties in design and manufacture of inertial guidance units, some missiles are being fitted with hybrid guidance systems. The Snark, for instance, is supposedly guided by an inertial stellar system while the Air Force's Thor and Titan are rumored to be controlled by a radio-inertial system. A pure inertial system is the ideal, but it may be a long time before components of sufficient accuracy can be manufactured so that missiles will be capable of hitting small targets at 5000 mile ranges.

Meanwhile, more and more companies are entering the field, and more money is being spent in development. There is at present a great number of different types and arrangements of accelerometers, gyros, and integrators being developed by different companies.

Eventually, an arrangement will be found that has satisfactory accuracy. Our defense cannot be complete until an adequate missile guidance system is found, for no missile, no matter how large or powerful, is any good unless it can hit its target.

WATER FOR ANCIENT ROME

by

Richard L. Jarvis, CE '58

At the time Julius Frontinus was appointed Water Commissioner of the City of Rome in 97 A.D. the Roman citizen enjoyed the amenities of a water supply system not to be equalled for a thousand years after the fall of the Roman Empire. Water flowed steadily into the city at a rate of 270 million gallons a day, nearly three times the amount which flows into Rome today, and equal to the daily supply for the city of Philadelphia.

Unfortunately, Roman engineers who designed this marvelous system were unwilling to adopt a theoretical approach to their work of supplying water for Rome. As a result they arrived at many erroneous conclusions and encountered a good deal of confusion in the construction and administration of their water supply system. However, in spite of their ignorance of theory and the crude instruments with which they worked, the Roman engineers displayed a genius for practical solutions which were primarily empirical in nature, yet adequate in content.

The engineer-architect Vitruvius describes in his sixth book on architecture the methods of water supply which were in use during the latter part of the Republic, and the early part of the Roman Empire. It is amazing to see how closely they resemble our present methods of water supply. Let us consider their methods of finding a water supply, the means used for conveying this water to the city of Rome, its distribution to the populace, and finally its administration.

Methods Used To Get Good Water

At times the availability of water from neighboring rivers is not sufficient to meet the demands of a growing city, and indeed river water may not always be desirable, in which case it may be necessary to locate springs supplied by groundwater. At this time five of the seven Roman aqueducts were supplied by springs, and one of the intakes on the river was being moved because of the muddy condition of the water after a rainstorm.

Where such springs are not found to be flowing in the open, Vitruvius recommends the following procedure for determining the probable location of underground water. Just before sunrise the observer should lie prone on his stomach with his chin resting on the ground. By looking around at the horizon, he may notice where moisture seems to curl upwards and rise into the air. Most likely water will be found in this area. Vitruvius also mentions the amount and quality of water likely to be found in certain geological formations. A clay supply is apt to be thin and scanty near the surface of the earth and not of the best quality or flavor. Water found in black earth is likely to have excellent flavor. A water supply found in coarse gravel, common sand and red sand is more certain, and of good flavor. Waters found in red rock formations are usually copious and of good quality, while water obtained from flinty rock formations is abundant when situated at the base of a mountain. Vitruvius points out that springs situated on level ground are usually salty, lukewarm and unpleasant tasting unless they flow from the mountains underground and break out in the middle of fields.

When a good site appears to have been found, Vitruvius recommends digging a hole three feet square and five feet deep. About sunset a bronze or lead vessel smeared with oil should be placed in the hole upside down and covered with leaves and dirt. The following day uncover the vessel, and if it is filled with droplets of water the presence of water is confirmed.

In general, we are told that water found in the mountains and northern regions is of sweeter quality, more wholesome, and more abundant. This Vitruvius attributes to the shadows of the trees and mountains which prevent evaporation, and to the melting of the snow on the mountains which ac-

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The aqueduct Alessandra constructed in 226 A.D. is marvelously well preserved. Because the Romans insisted that a pitch or fall of six inches to one-hundred feet of conduit always be maintained, this aqueduct, like many others, had to be built on high arches across valleys.

cumulates in the valleys. He also observed that when the moisture clouds from the south met the barrier of the mountains they burst and precipitated in the mountain regions. He further believed that the warm winds from the south pick up moisture which is later precipitated when these clouds meet the cooler air currents of the north. He substantiated this by pointing out that all the great rivers of Europe and Asia had their sources in the North.

Conduits Carefully Designed

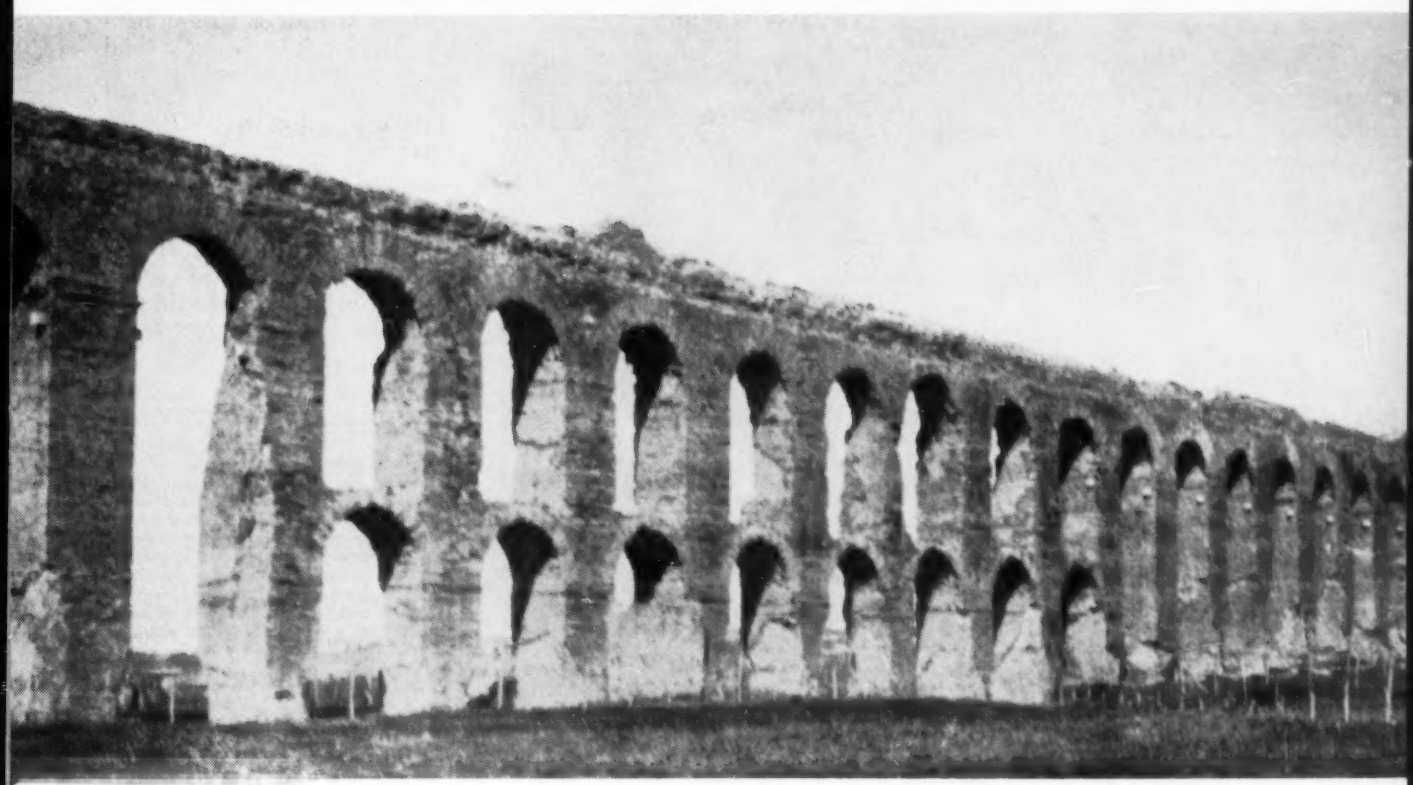
Once the source of water supply had been established, the Romans had three ways of conveying it to the city. They used conduits which formed artificial channels, lead pipes, or earthenware tubes. The characteristic of this water flow was either under pressure, or gravity flow in open channels. It is obvious that the Romans were able to convey water in pipes under pressure, which often was as high as twenty atmospheres or approximately 300 psi; however, they avoided doing this whenever possible. They took great pains in building elaborate arches to support the water channels at a level corresponding to the hydraulic gradeline. The channels were laid without exception on a six inch fall in one hundred feet. This often forced them to bring the water to the city in a round about way in order to provide the necessary fall. Their reason for doing this was probably to provide a steady flow condition at every section of the conduit and thus reduce inordinately high velocities and overflow conditions.

The reason they avoided using pipes under hydrostatic pressure, which is now common practice, is probably due to the large amount of leakage which resulted, and which we will later see amounted to a significant portion of the flow in many of their conduits. In addition, in order to withstand the water pressures, they were forced to use lead pipes which were expensive and very difficult to transport due to their excessive weight. Vitruvius also recognized the unhealthy effect of transporting water in lead pipes, and wherever possible the Romans used earthenware pipes. However, they could not withstand significant hydrostatic pressures, and in certain situations lead pipes had to be used.

If hills existed between the water supply and the city, tunnels were dug underground and leveled to the prescribed fall of six inches in one hundred feet. Levels were established by the chorobates. Vitruvius recommended that the chorobates be used, because it was most accurate. Many of the Roman engineers had some reservation about using a water level, based on Archimedes' statement that the surface of water is not level, but spherical.

If a channel was cut through a formation of stone or tufa, the rock could serve as the channel bed. If the cut was through soil or sand then a bed and walls had to be constructed. Where a conduit broke through a mountain and had to be carried across a valley, it often became uneconomical to support the channel on arches at the desired elevation corresponding to the hydraulic gradeline. In such a case it became necessary to construct a lead pipe conduit under pressure.

The Romans were quite ingenious in the construction of such pressure lines. They took care not to make their pipe bends too sharp, as a large change in momentum of the huge quantity of water resulted in correspondingly high forces on the pipelines which could destroy them. In addition they made sure that the angle of bend coming down the valley slope was equal to the angle of bend going up the next hill, thus balancing the forces of change in momentum. Although the Romans had no mathe-



matical conception of such forces, they were able to recognize their presence and deal with them in a practical manner. Standpipes were inserted in the pressure conduit in order to relieve the pressure of entrapped air. Today air relief valves are used instead of the stand pipes, but they serve the same purpose.

The Roman engineer made a practice of placing intermediate reservoirs every 24,000 feet along the conduits in order to facilitate repairs. Today cutoff valves are used in place of the intermediate reservoirs in order to isolate any portion of the line. The only significant changes in water supply between this period of Roman history and our present day practice is our more extensive use of valves, pressure conduits and pumping stations.

For 441 years after the founding of Rome the water drawn from the Tiber and local wells and springs proved sufficient to meet the demands of the people, but with a growing population the Romans were forced to go beyond the city for their water supply. The first of the many aqueducts to come, was the Appian aqueduct brought to the city by Appius Claudius Crassus, referred to as the Blind Censor and equally famous for his achievements in road building, in particular the Appian Via.

The conduit constructed around 313 B.C. had its intake on the Lucullan Estate between the seventh and eighth milestone. The total length of this conduit was 11,190 paces or approximately 12.2 miles. Nearly the entire structure was carried underground or on substructure foundations, while 300 feet was supported on arches near the Porta Copena. The second aqueduct to be brought into the city was Old Anio constructed around 273 B.C. Its source was considerably farther from the city than the Appian, located above the Tiber at the twentieth milestone outside the gate. Its total length was 43,000 paces or 47.0 miles; however, it meandered over a considerable detour necessitated by the high elevation of the intake, and the need for maintaining the prescribed fall. Again the major portion of this conduit ran underground, with slightly more than 1000 feet carried on arches. The Water Commissioner Flaccus was responsible for its construction.

By 146 B.C. the aqueducts Appia and Old Anio had become leaky by reason of age, and water was being unlawfully diverted. The Senate commissioned Marcius to reclaim and repair the two existing conduits. Marcius on his own initiative undertook to deliver a third supply which was to be the greatest of the Roman aqueducts. The cost of the new project was 180,000,000 sesterces or approximately $7,000,000 dollars. The intake of Marcia was located at the thirty-sixth milestone on the Valerian Way. Its length was 61,710 paces or 67.4 miles, 59.0 miles being underground conduit, and 9.4 miles carried on arches or masonry superstructure.

The two illustrations of the Claudia aqueduct shown on this page give a view of the system as it stands today. Built in 38 A.D., the Claudia had sources which were next to Marcia in excellence. The aqueduct was fed by the Caerulean and Curtain springs located at the thirty-eighth milestone on the Sublacensian Way. Its total length was 50.6 miles, of which 39.6 were subterranean channels.

Between 127 B.C. and 97 A.D., the year Frontinus was appointed Water Commissioner, four more major aqueducts, the Claudia, New Anio, Julia and Tepula were constructed.

Before investigating the distribution of water within the city, it might be appropriate to view the construction methods and materials of the Roman aqueducts. Although the individual ruins of the conduits are easily distinguished, the period in which the construction took place is more difficult to ascertain. Some of the earliest aqueducts such as Appia, Old Anio and Marcia were repaired, and in places completely rebuilt four or five times.

Consider the aqueduct Marcia, being the most splendid of the structures built, keeping in mind that its dimensions would be typical of those found in the Claudia and New Anio, but much larger than those of the Appia, Tepula, Julia, and Virgo. A typical cross-section of Marcia's original concrete is approximately five feet wide and nine feet high. The channel was always covered in order to prevent evaporation. In most cases an arch roof was used, having a rise of two feet above the impost or top of the channel wall.

The thing most unusual about these channels was the relatively high ratio of height to width, close to two in many cases. It can be proven by the manipulation of flow equations that the most economical proportions of any rectangular channel has a ratio of height to width of one half. Although the Romans did not have access to any such flow equations, being the amazing empiricists that they were, one is a bit disappointed that they chose the section they did. However, on further consideration one sees that the necessary arch roof encouraged them to keep the channel as narrow as possible.

The construction of the channel walls and supporting substructure consisted of coarse concrete faced with block and brick work of a poor type. Their concrete was a little different from what we have today.

They made mortar of coarse river bed sand and pozzolana or fine white lime. They then layed their aggregate which varied in kind and size in a bed of this mortar. Actually this type of construction would be termed uncoarsed rubble rather than concrete by present day standards. The facing of this rubble was very irregular, and the mortar joints were very wide, varying from one to three and one half centimeters, or up to one and one half inches.

The massive walls which supported the channel were from nine to ten feet thick, having buttresses on the side three feet wide and five feet long. The supporting walls and buttresses were made of medium poor concrete faced with coarse reticulate, having stone quoins or cornerstones.

The Distribution Network

Let us now proceed to the distribution of the water within and around the city of Rome. Five of the aqueducts existing at the time of Water Commissioner Frontinus had sufficient hydrostatic pressure head to deliver water to any point within the city. Of these the New Anio was the highest, then Claudia, Julia, Tepula, and Marcia in that order. The lowest head available was that of the Alsietina which supplied the ward across the Tiber and the very lowest districts. Six of the aqueducts were received in covered catch basins on the city side of the seventh milestone on the Latin Way. Here they had a chance to deposit sediment. The Julia, Marcia and Tepula were carried by the same arches from the catch basins to the city. When these conduits, flowing underground, emerged from the Viminal Hill, which was the northeasternmost of the seven hills of Rome, the flow was divided.

The water from the various aqueducts was then distributed in more than 200 reservoirs throughout the city. The waters from the reservoirs were distributed in such a way that no ward or district was completely dependent upon the flow from a single aqueduct. In this way no area would be without water should one of the aqueducts be out of service for a period of time. From the water mains leading from the reservoirs smaller pipes were tapped and fitted with nozzles having a rated capacity.

The size and character of the ajutage, which is what the Romans called the nozzle which fitted on the end of the water pipe, was extremely important, because it proportioned the water discharge. Since water flowed into a residence continuously, rather than intermittently, as is present day practice, the owner was charged for the size ajutage which he had, not for the amount of water which he needed.

The Roman engineer recognized that the size of nozzle and pipe alone did not determine the quantity of water delivered. It was also a function of the velocity of flow which in turn effected the hydrostatic pressure. The length of flow also contributed to the head loss and resultant lower hydrostatic pressure at the nozzle. In essence Frontinus said, "Let us remember that every stream of water whenever it comes from a higher point

(Continued on Page 50)

Close-ups of the Claudia aqueduct show the Romans' masonry skill was of poor quality by present-day standards. Their bricks were very thin (from three-quarters to one-and-one-half inches thick), while their mortar joints were very wide. In addition the wall facing was very irregular.

Preventing Aircraft System Failure Through . . .

NEW TECHNIQUES OF ANALYSIS ENGINEERING

by

David S. Kessler, ME '62

Complexity of modern aircraft is making it increasingly difficult to lick problems of systems failure. New groups of specialists called analysis engineers are tackling the challenging job, and graduating engineering students with an analytical bent might do well to give some thought to the career possibilities in this field.

In the past the aircraft manufacturer was concerned primarily with a sound structure when he thought in terms of flight safety. The hydraulic, electrical, and related systems of the aircraft were formerly thought of as auxiliary, and the loss of any one of them was not considered a serious problem. Today, however, flight safety is to a large degree dependent upon the operational integrity of the complex mechanical, hydraulic, pneumatic and electrical systems.

Operational integrity, with which the analysis engineer is concerned, implies a harmonious blend of all design requirements to yield optimum performance with respect to all of the operator's needs. But much difficulty is encountered in actually trying to tailor design specifications to the operator's needs.

First, since equipment is developed on a trial and error basis, there is a difference between the experimental model and the production item. A long and critical period of debugging must precede the item's use in the field. Second, equipment is never good enough for all possible applications, since additional uses for it are always being discovered. Third, the item might encounter unforeseen environmental conditions for which it was not properly designed. Design specifications, therefore, are based on estimates of future needs.

Debugging Has Become Impractical

The practical method of developing new equipment has been the basis for our technological advancement. Today, though, as we advance further and further into the realm of the unknown, we would like to know, before spending millions of dollars on a project, whether or not it will be successful. The cost of the time-honored debugging process of testing has made it an impractical method. The solution to the problem is that the debugging process must be done in advance, while the item is still on the drawing board. This is a great challenge which the analysis engineer is meeting.

No one knows how to foresee new uses for a product, nor how to predict the effect of natural phenomena. But in recent years, new techniques have minimized the need for debugging after a test model has been built. Progress in this specialized field has been rapid, and several formal methods by which an analysis team can test the operational integrity of a system have been developed. The failure-effect analysis is the first step in such methods.

Failures Studied

There are three basic types of failures. The first is the initial failure which has to do with manufacturing procedure. Initial failures can be reduced by better quality control. Second is the wearout failure. The third type of failure is the random type failure. For example, the most frequent cause of wristwatch stoppage is random failure. Analysis engineers are concerned primarily with the third type because it is the one upon which they have the least control.

Referring to watches again, what if one's life hinged on whether or not his wristwatch continued to operate? To insure his life, he might pressure the watch industry to design better watches, but this would require thousands of research programs which could conceivably run into a great deal of money. What is the solution, then? The answer, of course, would be to carry two or perhaps even three watches to be extra sure that a failure wouldn't claim one's life. Still there would be a slim chance that the three watches might fail simultaneously. One of the problems that analysis engineers face is that of how far to go in duplication of parts so that failures will not occur simultaneously. It will be seen that the problem becomes one of just how reliable a system must be.

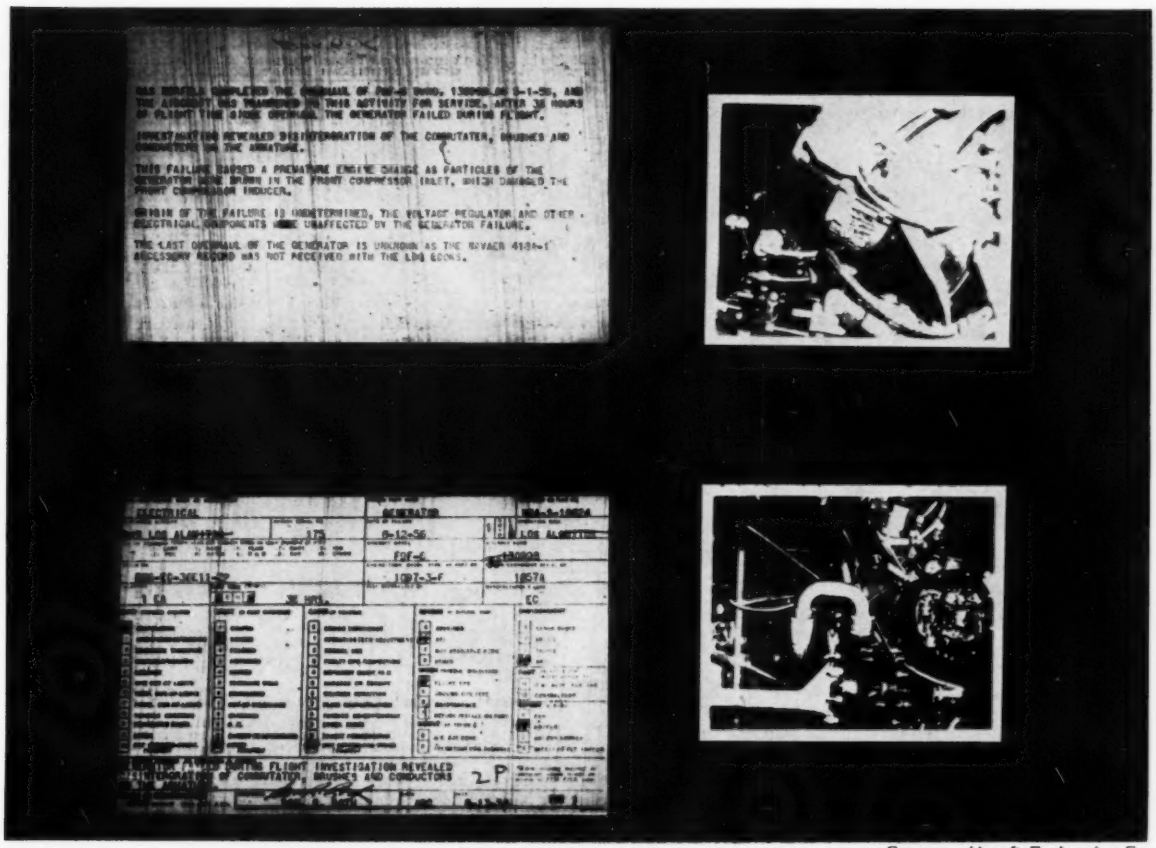
Sources of Trouble Data

Reliability analysis is the second method by which analysis engineers test the operational integrity of a system. A quantitative reliability analysis is an important tool in evaluating competing proposals. Reliability, as used here, is the probability that no failure will occur which will prevent the completion of a successful mission.

To assist the analysis engineer and help make his job easier, a system has been devised that brings data on empirical failures and replacements directly to him. These data are taken from flight and laboratory tests and from trouble records received from operating activities. For instance, the United States Navy requires, from each of its stations throughout the world, the submission of a formal report for power-operated primary flight-control systems. The Navy specifies that each critical system component shall be assumed to fail in the most adverse condition or positions. Each report must discuss the consequences of the failure and the compensating provision in the system, and each must evaluate the reliability of the critical component.

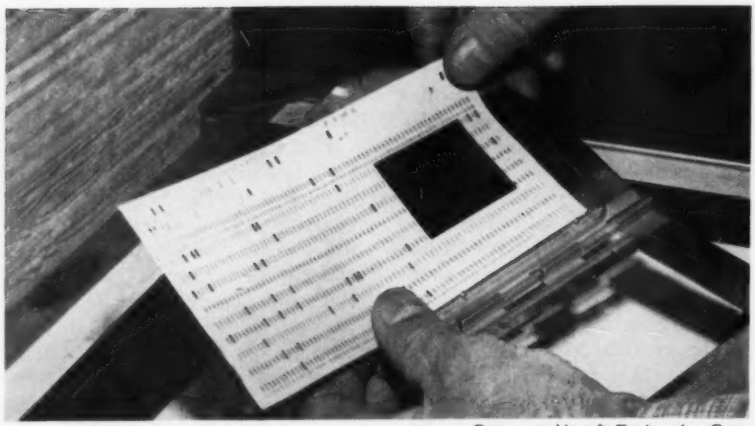
Formerly, the main source of trouble data was the laboratory or flight test system. In this system, a component is operated until a failure occurs. The failure is repaired and the procedure continues until the component wears out completely. The data accumulated are a good base for calculating failure rates. But these tests do not produce the exact environmental conditions encountered in actual service. Therefore, experience and judgment are needed to determine how significant the tests are compared to the actual operating requirements.

Failure reports from different parts of the world are received in a Central Service department. These reports are then forwarded to in-



Grumman Aircraft Engineering Co.

A blow-up of microfilm insert in an AMPFUR card shows how special information can be conveyed by putting it on film. The front (top) and back views of the FUR form describe a faulty generator. Two photographs of the generator itself, add to the data punched on the card.



Grumman Aircraft Engineering Corp.

Microfilm goes pickaback on this IBM card. The U.S. Navy uses AMPFUR cards to notify contractors of discrepancies on planes in service.

terested aircraft companies. They are screened by the engineering department of the company for material failures which may yield information on environmental conditions or design requirements.

However, to compute failure rates complete data on a known sample must be obtained. The system of obtaining operating and trouble reports that will be described was initiated in 1955 by the Bureau of Aeronautics. It is perhaps the most comprehensive and intriguing system in existence. All units throughout the world must report every failure, replacement, or unsatisfactory condition as it occurs. Reports are made on one of two simple forms: the Failure, Unsatisfactory, or Removal form (FUR) and the Electronic Failure Report. The information on the forms is reproduced on IBM machine cards. If the reports are amplified (AMPFUR), the IBM card is supplemented with an attached microfilm.

This unique trouble reporting system encompasses the entire population; consequently, it provides a good base for statistical analyses. The reporting forms are simplified to minimize the paper work load on field units. Under this new system the job of the field mechanic is merely to identify the failed part and to make other factual observations. No request for an engineering analysis is made on the FUR form, since such requests require special skills not normally found in operating units. Necessary engineering analyses are performed at the aircraft plant by a group of engineering specialists. In contrast, the old method provided that a report should be written when the engineering officer thought something was so bad that it was worth reporting.

All trouble reports received at the aircraft company are reviewed for evidence of possible design deficiencies and then are processed and filed so that pertinent information is available at a moment's notice. The bulk of the trouble reports consists of FUR's rather than AMPFUR's. Therefore, the AMPFUR's follow a different filing process than the others. Both reports, however, are commonly filed by aircraft model and by part numbers.

In filing trouble reports a unique account numbering system is employed. The account number is a six-digit number which greatly simplifies machine card processing. When a single report refers to several failed parts, a copy of the report is filed under the account number of each part. For parts not previously processed, the first step is the establishment of the part

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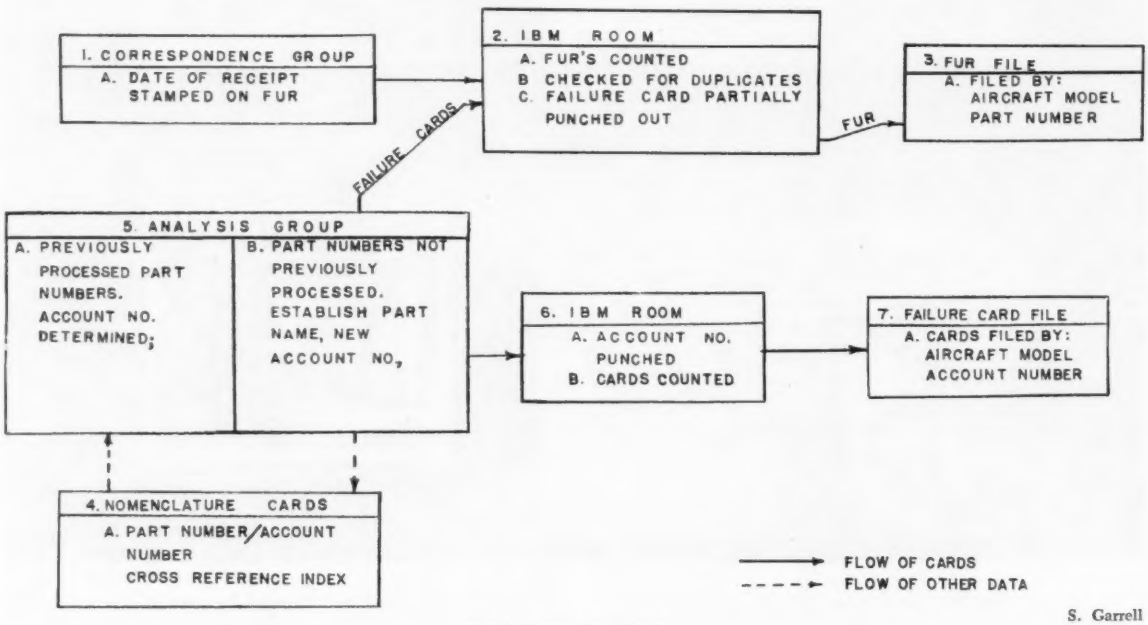
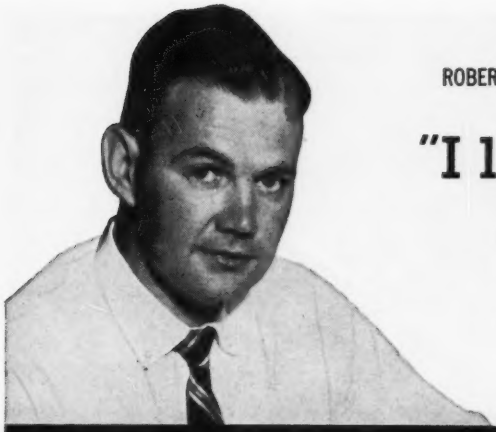


S. Garrell

FUR Processing Cycle



ROBERT H. SWISHER, B.S.E.E., GROVE CITY COLLEGE, '54, SAYS:

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"I'm a radio transmission engineer for Bell Telephone Company of Pennsylvania. My work is interesting and full of variety, and I get all the responsibility I can handle. Have a look at today's assignment, for example —and see for yourself."

"8:30 a.m. I'm at my desk applying a new method for overcoming interference on Pittsburgh's mobile radio channels. It involves operating inactive channels on reduced power."

"10:45 a.m. Before any modifications can be made, it's important that I check apparatus and wiring options. That's what I'm doing here at the Remote Control Terminal equipment."

"1:30 p.m. After lunch, I take a company car out to the transmitter tower site. Here I check wiring and explain our plan to one of our mobile radio maintenance men."

"3:15 p.m. I review my proposed modifications of auxiliary control circuits with Supervisor Sid Graul. Now I'll prepare work orders, and next week we'll make operational tests."

"Final phase. The operational test is made from an actual mobile radio unit. I'll make test calls and monitor the channels from various points within the Pittsburgh area."

"See what I mean? I really get to 'carry the ball.' Soon I'll be taking a special course in advanced electronics at Bell Labs—a great opportunity. As I said —I like my job."

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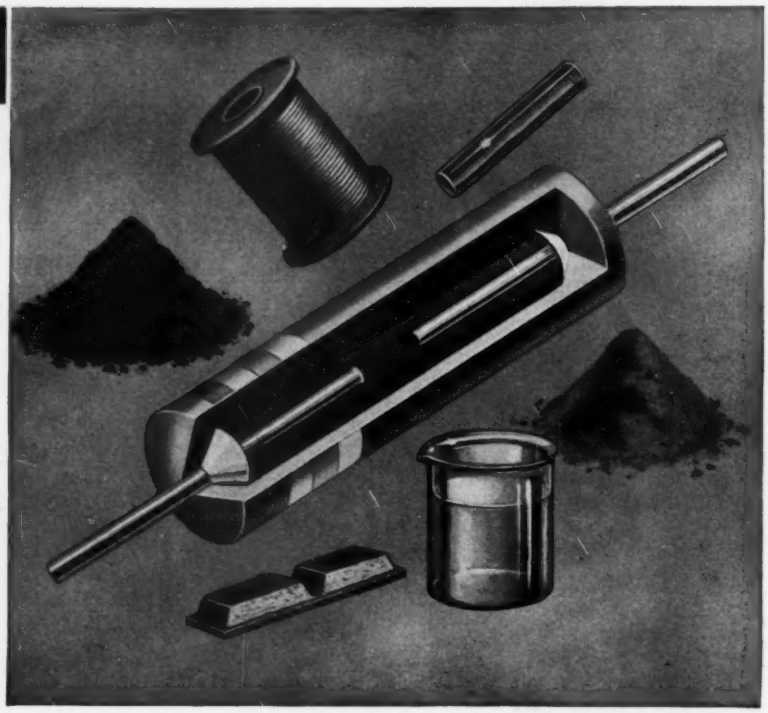

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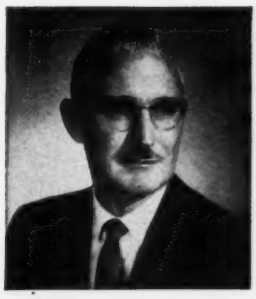

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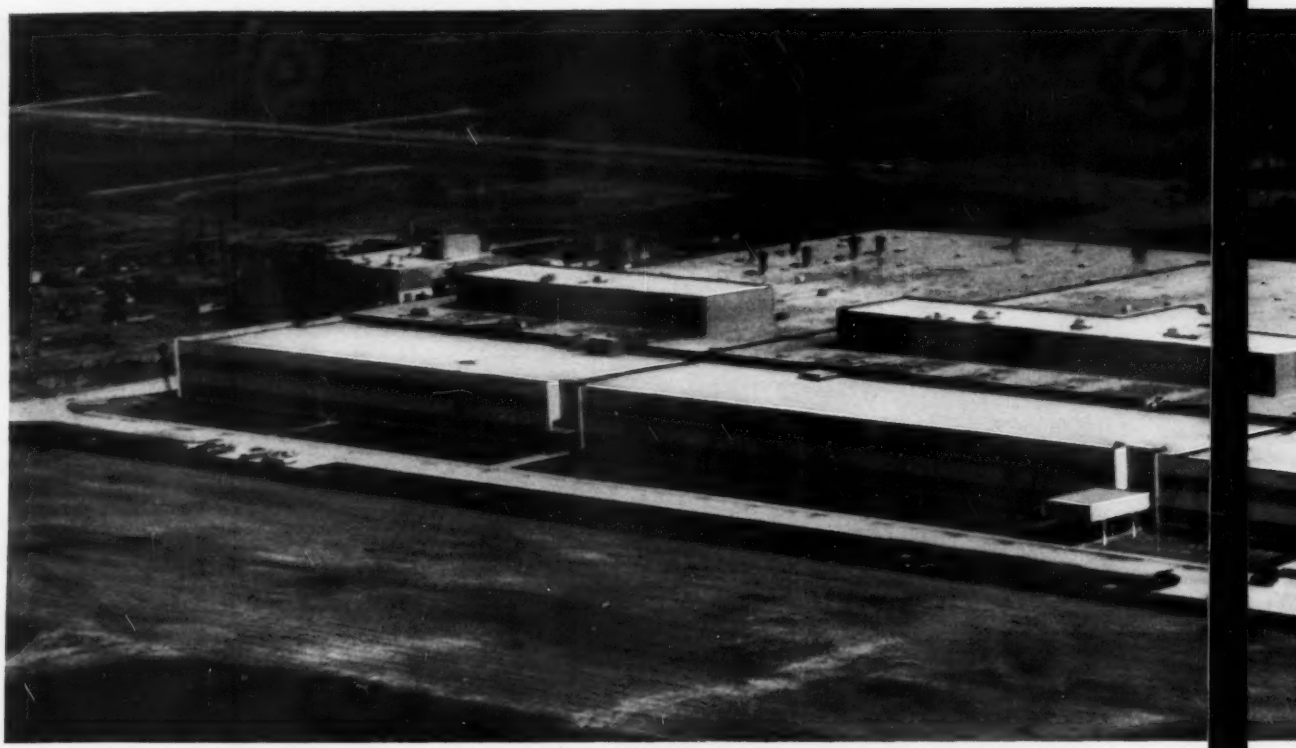
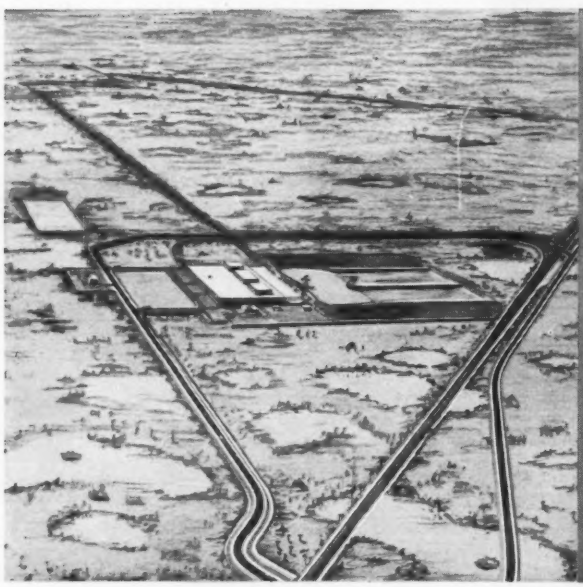
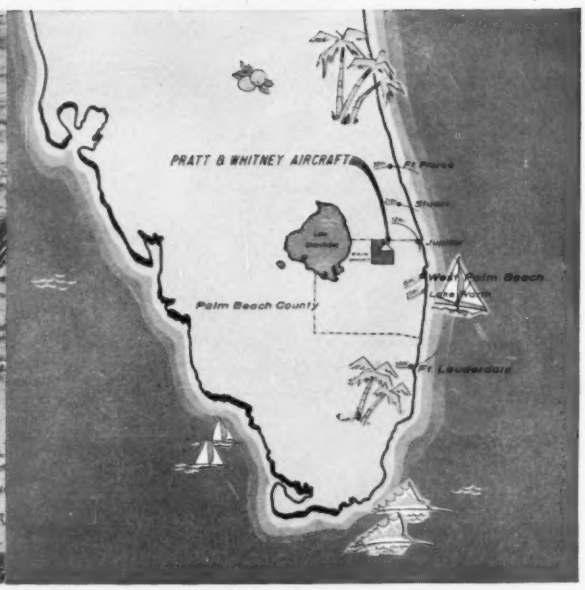


FLORIDA RESEARCH AND





ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four miles in the background.

LOCATION—The new Center is located at United, Florida, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live in the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.

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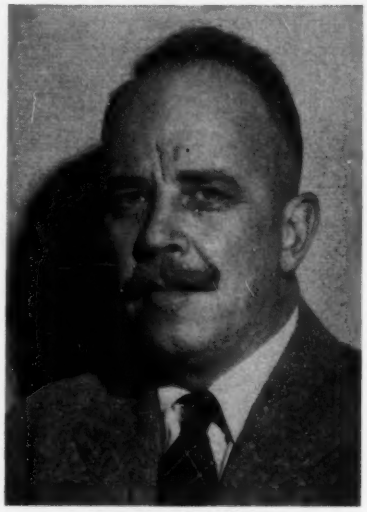


Roscoe H. Fuller

THE PRESIDENT'S MESSAGE—

IN PRAISE OF INDIVIDUALITY

There is in the town of Weston, Vermont a more or less unique institution known as the Vermont County Store. It is run by one Vrest Orton, a Vermonter who returned to his native heath to open a store dedicated to the principle of selling things people want. He says it is fun, and I guess it is.

Natives of the Republic of Vermont value individuality about as highly as any people on earth, and they are inclined to be self-sufficient to a degree that fills most of us with envy. But it is seldom that they have much to say on the subject for publication.

Among the bits of wisdom scattered through Mr. Orton's current catalog is an essay on "The Right to Fail" which comes close to describing the difference between our grandfather's days and ours, and which is about as good a plea for individual ambition as I have seen.

Mr. Orton quotes a professor friend of his as saying "The whole trouble is, young men today no longer have the right to fail." Enlarging upon this theme, he points out that by bolstering our young folk with all manner of guarantee and subsidy, we have deprived many of them of this classic American right. (He is speaking, of course, of failure in business, and not thinking of our Cornell, where the scholastic right to fail is not likely to be abridged.)

Some of his remarks are so apt that they should be quoted:

"What made the United States a great country was the strength, the inspiration and the drive of the individual. These individuals had vision, wit, imagination and stamina. Their numbers . . . set the pace to make this a great nation.

"What made this early American individual strong was his dare to fail. His energy and drive came from self-reliance, his courage and sense of rightness came from his integrity, and his capacity to lead came from his assurance that he could see the goal ahead and had the guts to aim for it . . . He had no government supporting him, he had no weakening unemployment compensation to keep him going when he happened to be out of work, he had no social security to keep him from saving and building a bulwark against old age. In fact all he did have that made him a man was his right to fail. And what made him a leader was the undoubted cold fact that if he *did* fall flat on his face once in a while, he had the courage and the pride to get up off the ground and make a fresh start.

"Today parents who really want to practice this great early American way of life and teach their kids to have stamina, guts, faith and integrity, are constantly defeated by the welfare state that the Federal Government has imposed upon us in spite of ourselves. Today when the federal powers can force us by law to accept social security, unemployment payments, and various and sundry surtaxes, they are not only weakening the old-time powers of the American individual but they are insidiously weakening the determination of our sons to be individuals and to make their own way toward the top."

There is more to the article, and it is worth reading.

If we stop to think over Mr. Orton's remarks we realize that the right to fail goes along with the opportunity to succeed. Both were taken for granted as American principles not so many years ago, and both have been considerably abridged within the last twenty-five.

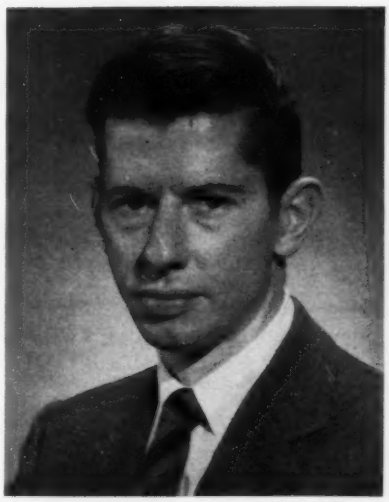
Some people profess to believe that if we allow 5% of the folks to rise to the top we are unfair to the other 95%. "Undemocratic" is a word they use. They would like everyone to be pressed in the same mold; everyone to be secure "from the cradle to the grave", and they deplore individuality, risk, and the right to fail (or to succeed). Their ideal appears to be a people as alike as holes in a punched card, with them doing the punching.

Resist, ye who can see! Let not yourselves be standardized! The right to fail is the precious other half of the right to succeed, and the right to differ from standard is the leaven which raises a society above the communistic mediocrity of the ant.

ROSCOE H. FULLER

ALUMNI ENGINEERS

John P. Craven, CE '46, who is contract research administrator on the staff of the David Taylor Model Basin, Potomac River Naval Command, Department of the Navy, was nominated for special recognition during the 1958 Engineers & Architects Day observance. John is considered one of the foremost hydrodynamicists in this country, having worked with underwater mines, the first nuclear submarine, and the Navy's Polaris missile program. He has a MSCE from Cal Tech and a PhD from George Washington University. As a sideline, he is now completing work for a law degree.



Alumni News

John P. Craven

L. K. Stringham, EE '33 has been elected vice president, research and development, of the Emerson Electric Manufacturing Company of St. Louis, it was announced recently.

Prior to his resignation, Mr. Stringham had been with the Lincoln Electric Company of Cleveland, Ohio, since his graduation from Cornell, and was serving as that company's vice president in charge of engineering and as a member of its board of directors.

Mr. Stringham was director of welding development and was then chief engineer at The Lincoln Electric Company before he became vice president in charge of engineering. He pioneered in developing agglomerated fluxes for the hidden arc welding process and the equipment that made possible their application in industry. He also directed Lincoln Electric's development in the use of iron powder electrodes and of a universal welding machine that produces both AC and DC welding current.

Mr. Stringham holds many patents in arc welding. He is a fellow of the American Institute of Electrical Engineers and a member of its Electric Welding Committee. He has been active in the American Welding Society.

Michael Rapuano, BArch '27, of Newtown, Pa. and the firm of Clarke & Rapuano, consulting engineers & landscape architects in New York City, recently became the fifth president of the American Academy in Rome. Founded in 1894, the Academy is devoted to furthering the arts and humanities in the United States, principally through the granting of fellowships to American artists and scholars.

Alumni News

George H. Hutchinson

George A. Hutchinson, Jr., '33, '34 BArch, is one of two new partners appointed by Perkins & Will, architects-engineers, with offices in Chicago, Ill. and White Plains, N. Y. Laurence B. Perkins '30 and Philip Will, Jr. '28 are members of the firm which are the architects of the Engineering College and the proposed new Ithaca High School. Hutchinson, who has been with the firm since 1952, will assist in directing activities of the Chicago office. He was formerly with the Chicago Housing Authority, Federal Housing Administration, Chicago Plan Commission, and a partner in Kincaid & Hutchinson.

Roger S. B. Hartz, CE '13, secretary of the Baltimore and Ohio Railroad, retired September 30, having reached the age of 70. Mr. Hartz has been in the service of the B & O for 35 years and has been a member of the executive staff as its secretary since 1951.

After graduating from Cornell, Mr. Hartz went to Baltimore and, while engaged in the engineering construction business, was comissioned second lieutenant, Cavalry, U. S. Regular Army, serving four years on the Mexican border patrol and one year abroad during World War I. He continued his military activities in the organized reserves, and was promoted to the rank of colonel in 1934.

For several years after leaving active military service, Mr. Hartz was a construction engineer in Cuba and in Baltimore. In 1922, he became vice president of the Perkins Oil Company of Memphis, Tenn. The following year he came to the B & O as special representative in the office of the senior vice president in Baltimore. He was named assistant to the senior vice president of the B & O in 1941, and became assistant to the vice president-finance in 1942.

(Continued on Page 48)

Allied Chemical

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By elbowroom, we mean room for you to grow. As a man thinking about his career, you naturally want to join a company that gives you the chance to develop and use your talents to the fullest.

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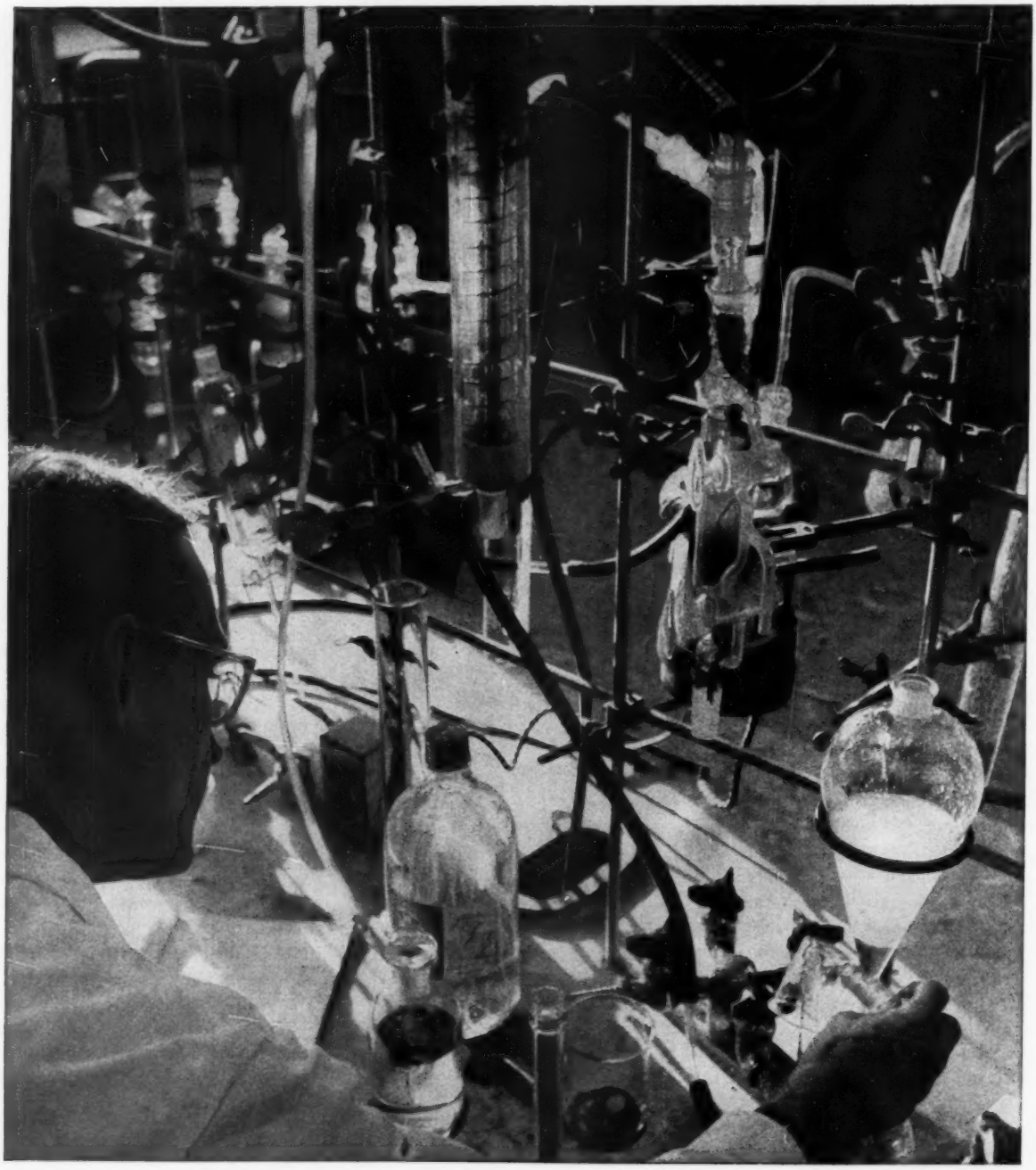


FIFTY YEARS AGO IN THE ENGINEER

It is to be regretted that such a small proportion of technical students and engineers just entering into the practice of their profession, seem to realize the importance of the work which the various engineering societies are doing; and that so many are totally indifferent in the matter of becoming identified with this work. These organizations are an extremely important factor in the advance of engineering science, and have much to give the young engineer, which he stands badly in need of. The free exchange of ideas and experiences, so indispensable to the development of any and all lines of human activity is probably more necessary for progress in engineering than in most of the other professions. The technical societies, by offering a medium for, and promoting such exchange, are leaders in the march of engineering progress, and have a value from an educational point of view far greater than is commonly supposed. Their proceedings and other publications are veritable mines of information, and the up to date engineer should be familiar with them.—(Sibley Journal—*March, 1908.*)

The college athletes have been very busy this last month. After pulling out and winning the basketball championship we have branched off into bowling and have been fairly successful in that line so far, having won from the Agricultural team and lost to the College of Law. On the 30th of March there will be a smoker in honor of the Civil Engineering teams. At this meeting fobs and shingles will be given out to the members of the different teams. Professor Woodruff of the Law School will deliver to Dean Haskell the cup representing the basketball championship which we have won.

On Saturday, March 20th the Annual Carnival of Sports was held in the Armory. Fully five hundred undergraduates were there to see the college teams go through the various events. At the close of the carnival the annual interclass and blind-handicap cross-country race was held. The Veterinary college team came in first and received the prize, two barrels of apples, which were promptly eaten by the undergraduates of that college. Arts was second, Civil Engineering third, Agriculture fourth, Sibley fifth, and Architecture sixth. The events were hotly contested and very exciting. Among the events were: the rope climb, wheelbarrow race, potato race, elephant race, three legged race, sack race and rooster fight.—(Cornell Civil Engineer—*April, 1909.*)

In a few days the Juniors will vote on whether or not the Honor system is to be retained. Is it possible that it is going to have a life of only one short year? We sincerely hope not. To the Seniors who have worked under both systems, there is only one answer possible. Keep it, even if every man in college "busts." A man caught masquerading with a stolen diploma would not receive much mercy, and getting one by cribbing is worse. Keep the honor system, even if it is not approved of by the faculty. Now it is not officially recognized. There are just as bad punishments as being unostentatiously dropped out of college. A man caught cheating at cards would not long have the respect of the students, and it would take him a long while to regain their respect.

Why should a student complain because a Professor stays in the room? It makes no difference in the honor of the case. This is a system run by the students and it has nothing to do with the faculty. If it were a fellow caught cribbing, in a moment of weakness, he would have no second chance. In the Senior class the fellows seem to have more responsibility and realize what it means to the college. Still they kick on having to sit in alternate seats. This is a University ruling and should be lived up to. It should be made part of the honor system and posted up with the other rules, and any one not living up to it should have a black mark put after his name. In cases of overcrowded rooms, an instructor's permission is all that is necessary. The farther away temptation is put the better. It is so easy to look at a paper right at your elbow and get the formula you want. The very strongest have been known to slip in times like this.

The honor system is the first thing a Freshman should be taught on entering the College of Civil Engineering. At the first meeting of the class they should be told of its work and what they are expected to live up to. It may be that

(Continued on Page 61)

COLLEGE NEWS

CORNELL ENGINEER WINS TOP AWARDS AT ECMA CONVENTION

The CORNELL ENGINEER received six major awards at the annual convention of the Engineering College Magazines Association held October 10–11. This was about twice as many as any other magazine won according to Jack Walsh, editor-in-chief. The awards were given for issues published between September, 1957 and June, 1958.

First and second place awards were received by Roy J. Lamm and Jeffrey Frey respectively in the competition for the best Non-Technical Article. Roy's article was the "Federal Highway System: Its Progress and Effects." Jeff wrote an article for the special IGY issue on "Exploring the Frozen Continent."

The magazine as a whole received second place as the Best All-Around Magazine.

Richard Brandenburg, past editor-in-chief, won two awards for his editorials. He received first place for the Best Editorial-Full Year and second place for the Best Single Editorial.

An honorable mention was received for the Best Covers-Full Year.

Professor E. B. Watson, a faculty adviser for the CORNELL ENGINEER, was elected vice chairman of the ECMA at the convention. There are forty six member colleges in the association.

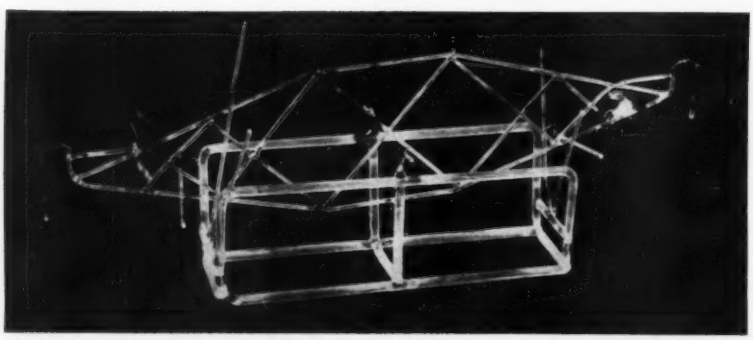
STUDENTS TAKE TOP THREE HONORS IN NATIONAL CONTEST

Five Cornell students received all of the top awards this year in the annual mechanical and structural welded design competition sponsored by The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio. This is the first time in the eleven year history of the competition that students in one engineering school have made a clean sweep of the three top awards.

The Lincoln Foundation makes 46 awards each year recognizing the engineering ability of college undergraduates in the field of welded design. Awards are made for both mechanical and structural designs which make a significant use of arc welding for improvement and lower costs. The Foundation also awards scholarship funds to the schools in which students were enrolled when making their designs.

Top award of $1250 went to Richard Jarvis, CE, for his design of a triangular shaped foot bridge. John Jenner, ME, and E. R. McLean, ME, shared the $1000 Second Award for the mechanical design of an automatic welding machine. Gordon Kraus, CE, and Robert Spicher, CE, designed a display arboretum which received the $500 Third Award. Honoring these awards, Cornell received $1750 in scholarship funds to be administered by the Mechanical and Civil Engineering Departments.

Four students also received sixth place awards for their design of a pedestrian footbridge. They are William P. Burke, David F. Davis, Lewis Friederick, and Harry E. Schlafman, all CE.



This six inch long glass structure is a part of a balance sensitive to one millionth of a gram. The apparatus, enclosed in a highly evacuated glass jar, is used for surface oxidation studies by the engineering physics staff.

CORNELL BUILDS MACHINE TO SIMULATE ROAD CONSTRUCTION

A kneading compactor designed by a California highway engineer, Mr. H. V. Hvreem, has been built by the civil engineering machine shop. This addition completes a set of equipment designed by Mr. Hvreem for testing bituminous road building materials. Two years were spent in completing this instrument. It is one of a very few in the country.

This machine is one of many instruments being used by the Civil Engineering School in the study of these bituminous mixtures. The project is headed by Prof. T. D. Lewis and has been in progress since 1950.

The work is supported by three agencies. The Potter Memorial Foundation, a fund for the scientific development of bituminous materials, supplied the money for the building of the compactor. ESSO Standard Oil Co. and the New York State Bituminous Concrete Producers' Association each grant annual fellowships to students who devote their graduate work to this project.

Prof. Lewis is looking forward to expansion of the work when the Civil Engineering School moves to its new building this spring.

ENGINEERING PHYSICS RENEWS CONTRACT WITH U.S. NAVY

The Navy has just renewed a contract with the Department of Engineering Physics for the purpose of studying the mechanics of surface oxidation. The original contract will end the first of next year, but in view of the progress made, the Office of Naval Research has

seen fit to continue sponsorship of this work.

The basic objective of this project as stated in the proposal by Assoc. Prof. T. N. Rodin and Prof. H. S. Sack of the EP school is as follows: "It is felt that the most significant contribution this group can make to the study of corrosion, or of surface physics in general, consists in investigating, as a function of surface conditions and other parameters, the early stages of surface reactions, and their relations to the later stages."

Previous work by two former Cornell graduate students done under the original contract have been published as theses, in partial fulfillment of PhD. degrees. Dr. R. R. Adiss' contribution concerns the kinetics of oxidation film growth on single magnesium crystals at elevated temperatures. This investigation involved the use of a microbalance, sensitive to increments of 10^{-6} grams in ultra-vacuum conditions. Dr. M. S. Cohen's work also concerns the oxidation of magnesium but deals principally with the correlation of initial rate of reaction with surface structure.

The new work under Prof. Rhodin and Prof. Sack's direction will continue previous investigations and will try to expand the program to include some of the transition metals and more exact measurements of the variables involved. A group of graduate students will also be working on this project.

This work is a part of a large overall EP program investigating surface physics in general.

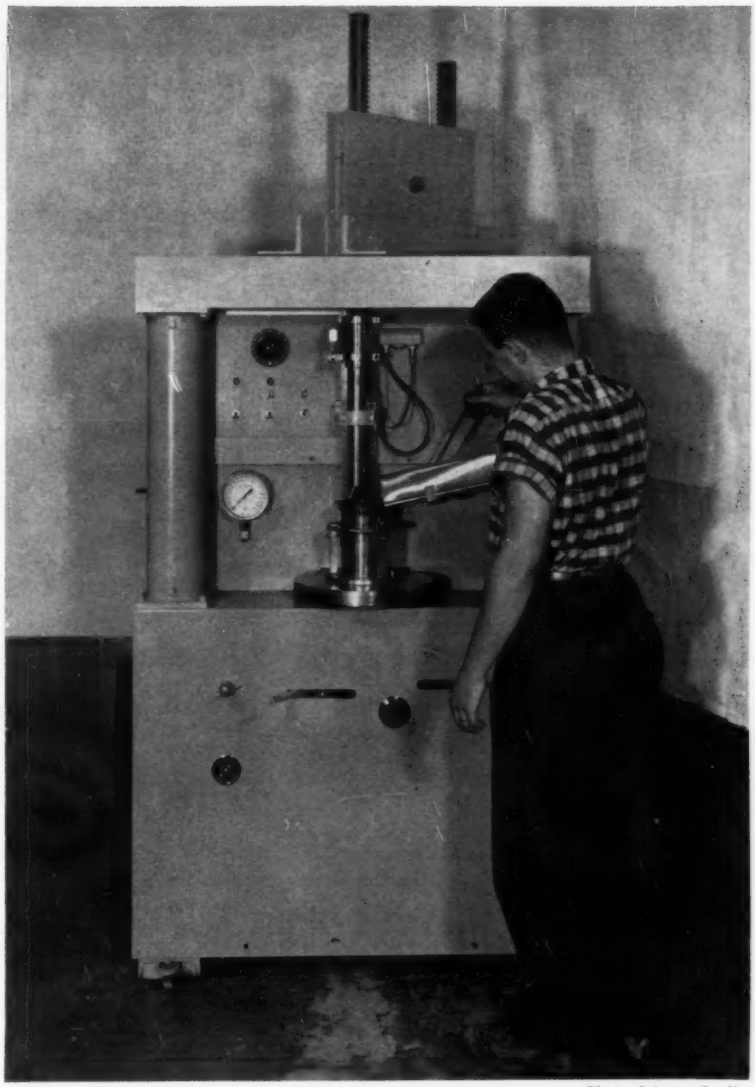


Photo Science Studios

The study of bituminous mixtures is aided by a kneading compactor built by the school of Civil Engineering. The machine simulates conditions encountered by these mixtures in actual road construction and insures realistic experimental results.

STUDENTS PLAN NEW CITY FOR WORLD'S LARGEST OIL RESERVE

Cornell graduate students will plan a new city this fall and winter which some day will rise on a site in the upper basin of the Colorado River where the nation's oil industry is preparing to tap the world's largest known oil resource.

The oil is in the huge rock formations that stretch across three states – Colorado, Wyoming and Utah. It is known as the Green River Formation and is named after the river that flows through Wyoming, a corner of Colorado and across Utah before emptying into the Colorado.

Scientists, after years of effort, have discovered processes through which the oil may be extracted from the shale at a cost low enough to make development feasible.

The city which the 30 Cornell students will plan and design will be the second largest in Colorado when it is erected. It will have approximately 350,000 inhabitants when it reaches its full growth and about 100,000 of them will be employed, directly or indirectly, in extracting oil from the shale that abounds in the area. It will be a city larger than either Omaha or Salt Lake City.

It is estimated that more than 1.5 trillion barrels of oil lie in the shale deposits in the three states. For several years the Union Oil Company, as well as the United States Bureau of Mines and other agencies, has successfully extracted oil from the shale on an experimental basis. Development of a new oil industry, based on the commercial extraction of oil from shale, will give this country not only greater oil resources than are now available this side of the Iron Curtain and probably in the world, but it would make the United States free from any dependence on oil from overseas sources.

The Green River Formation contains almost five times the known world crude oil reserves, and about 29 times the known crude oil re-

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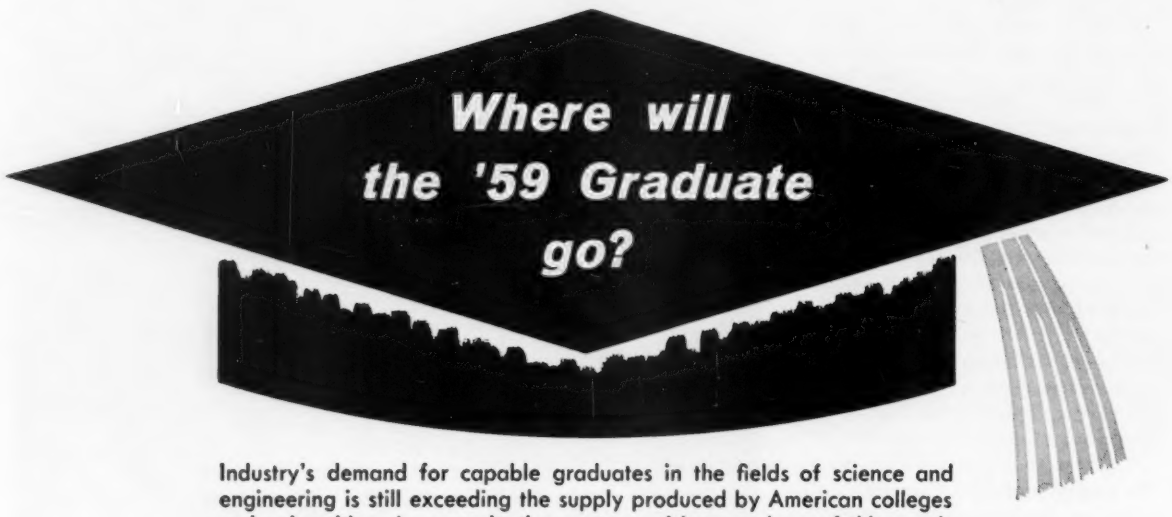
EENY

MEENY MINY

MO



Industry's demand for capable graduates in the fields of science and engineering is still exceeding the supply produced by American colleges and universities. As a result, the most promising members of this year's class may well wind up with a *number* of openings to consider.

In such circumstances, who would blame a bright young man for at least letting the phrase "eeny, meeny, miny, mo" slip through his mind!

Of course, there is one inescapable conclusion to be considered: openings are one thing, genuine opportunities quite another. Thoughtful examination of such factors as potential growth, challenge, advancement policy, facilities, degree of self-direction, permanence, and benefits often indicates that real opportunity does not yet grow on trees.

Moreover, the great majority of personal success stories are still being written by those who win positions with the most successful companies.

For factual and detailed information about careers with the world's pioneer helicopter manufacturer, please write to Mr. Richard L. Auten, Personnel Department.

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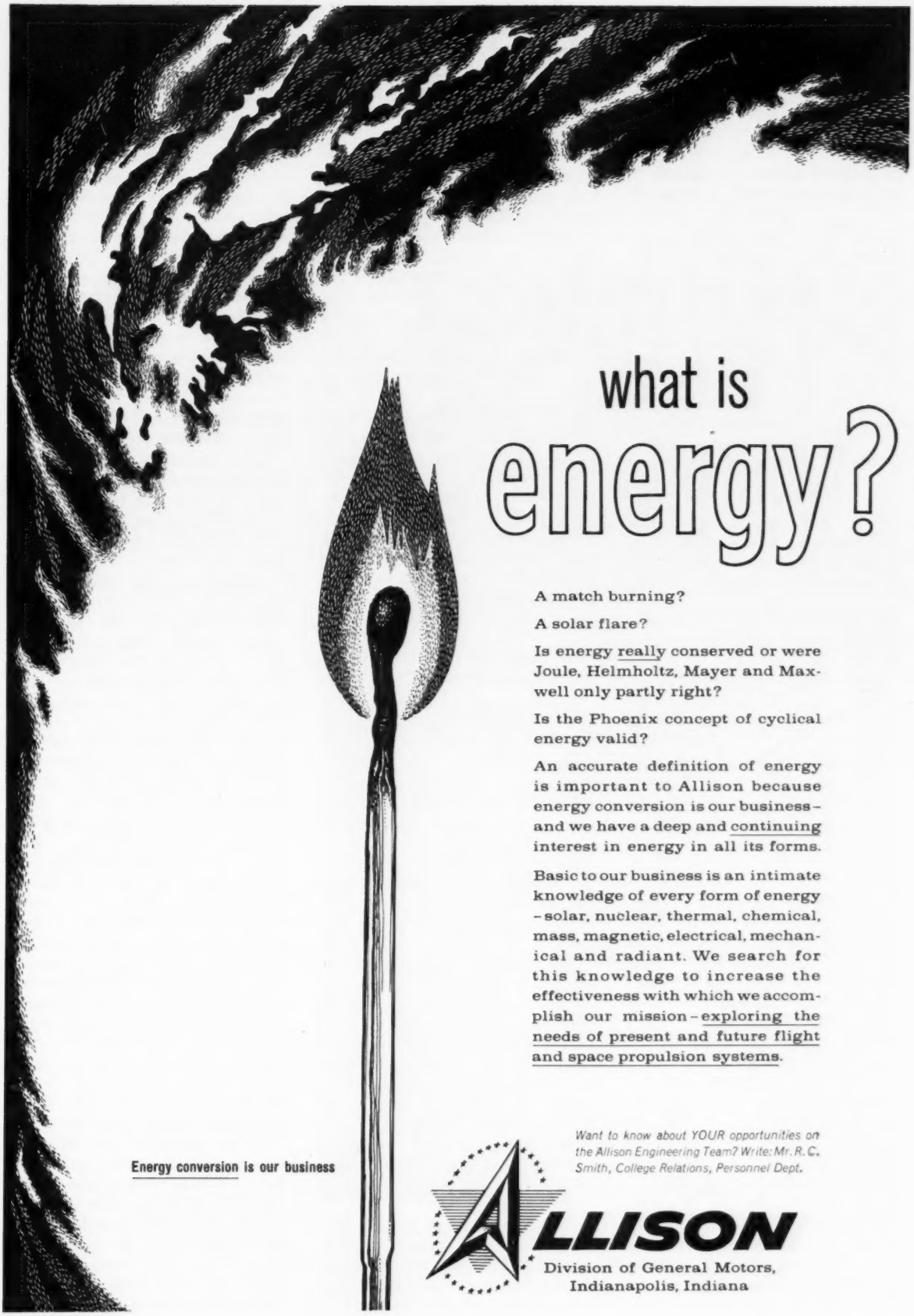

what is energy?

A match burning?

A solar flare?

Is energy really conserved or were Joule, Helmholtz, Mayer and Maxwell only partly right?

Is the Phoenix concept of cyclical energy valid?

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TECHNIBRIEFS

NEW PROGRESS MADE TOWARD ELECTROLUMINESCENT TV SCREEN

A new advanced type of television screen is being developed by Westinghouse Electric Corporation. Their experimental Elf Screen is brighter than any normal television picture tube but is no thicker than an ordinary picture frame. It combines in a single thin structure an electroluminescent panel and a built-in storage and control system made of ferroelectric materials.

The cathode-ray type picture tube used in most television sets has a number of disadvantages. The tube itself is bulky and largely determines the size of the set. The cathode-ray tube also allows very limited brightness and contrast. In some types of installations, the picture tends to flicker.

In an ordinary TV picture tube, the picture is painted on the phosphor-coated inner surface of the tube by a beam of electrons which sweeps across the screen, creating new pictures thirty times a second. Ordinarily, the phosphors glow long enough after each time they are excited by the beam that the picture looks continuous, but the fact that the phosphors are not continually excited reduces the average brightness of the phosphors and consequently the brightness of the screen. Also, in certain military applications, fewer than thirty frames per second are painted on the screen and there is a noticeable flicker.

The new Elf screen overcomes the problems of brightness and flicker by providing continual excitation of the screen. Ferroelectric cells control the excitation of the screen in accordance with electrical signals in such a way that once a certain picture is formed, the screen is excited to hold that picture until a different signal is received. The images can be stored on the screen for several minutes or can be changed many times a second. Because of the continual excitation experimental Elf screens can attain a brightness of three times that of the normal television tube and produce contrast ratios of as high as 200:1.

The use of the Elf screen would greatly increase the flexibility of TV sets as pieces of furniture. The set could quite conveniently be built flush with a wall and could be made in almost any size. In fact, Westinghouse scientists say that a screen the size of a window would be easier to produce than one the size of a normal cathode-ray tube.

The system is still in its early stages of development, however. The one feature of the cathode-ray tube which will not be easy to replace is the scanner beam. Scientists are now attacking the difficult problem of signal distribution, and the Elf screen may well be the solution to the long sought problem of "on-the-wall" television.

HIGH TEMPERATURE ALLOY TO INCREASE JET EFFICIENCY

Westinghouse Electric Corporation scientists recently announced the development of a new nickel-chromium-tungsten alloy, Nicrotung, for use in turbojet engines. Nicrotung should raise the operating temperatures of new engines about 150 degrees Fahrenheit. A temperature boost of 150 degrees just about equals the total increase in operating temperatures made in such engines over the past five years.

The breaking strength of the new alloy at room temperature is about equal to that of a good grade of structural steel. However, at 1700 degrees Fahrenheit, the metal can withstand a stress of 32,000 pounds per square inch, more than one hundred times the stress structural steel can withstand at this temperature. Besides this, the metal is easily cast and resists chemical attack from high-temperature gases.

Nickel was used as the base metal for the alloy because it is currently the most practical high melting point element. Chromium was added to provide resistance to corrosion and tungsten was added to increase strength. Then five other elements were added in smaller amounts to further enhance these properties.

This increase in the operating temperature of the jet engine is extremely important because each increase in operating temperature causes an increase in the efficiency and performance of the engine.

SCIENTISTS ON ANTARCTICA MAKE NEW DISCOVERIES

As a part of the program of the International Geophysical Year, scientists from the United States, Russia, France, and Australia are making studies of conditions on Antarctica.

Russian scientists are currently investigating the properties of the antarctic ice sheet and the continental glacier underneath. The depth of the ice has been found to range from about 4500 feet near the coast to over two miles, 225 miles inland. The depth of the ice sheet had previously been thought to average only about 1800 feet. Using the old data, it had been calculated that if the entire ice sheet were to melt, the level of all of the oceans would rise 150 feet. Using this new data, this calculated rise will have to be increased by at least a factor of three.

Whether Antarctica is a true continent or merely an archipelago has long been a matter of conjecture. No absolute answer to the question has yet been obtained; however, it is definitely known that if Antarctica is a continent, it is much smaller than the ice sheet which covers it and also much smaller than it is indicated to be in most geographical literature.

Geomorphological expeditions have compiled information about the ocean bottom along the eastern coast of Antarctica. The data obtained about the ocean bottom in this region tends to support the theory that the continent Gondwana once joined Antarctica with Africa and Western Australia.

ACCURATE PREDICTIONS OF ATOM FUEL LIFE SOUGHT

One of the nuclear industry's most serious roadblocks is its dependence on theoretical calculations to determine reactor behavior under actual operating conditions. The Babcock & Wilcox Company expects to place this phase of power reactor technology on firmer ground through the use of a combined research and test reactor and "hot exponential" facility.

The new unit will provide industry with a means of determining accurately how reactor cores will behave at operating temperatures. In the past reactor behavior for these conditions has been determined by calculations based on experiments at room temperatures. Now, with this new facility, the first of its kind in the country, reactor characteristics at high temperatures can be measured.

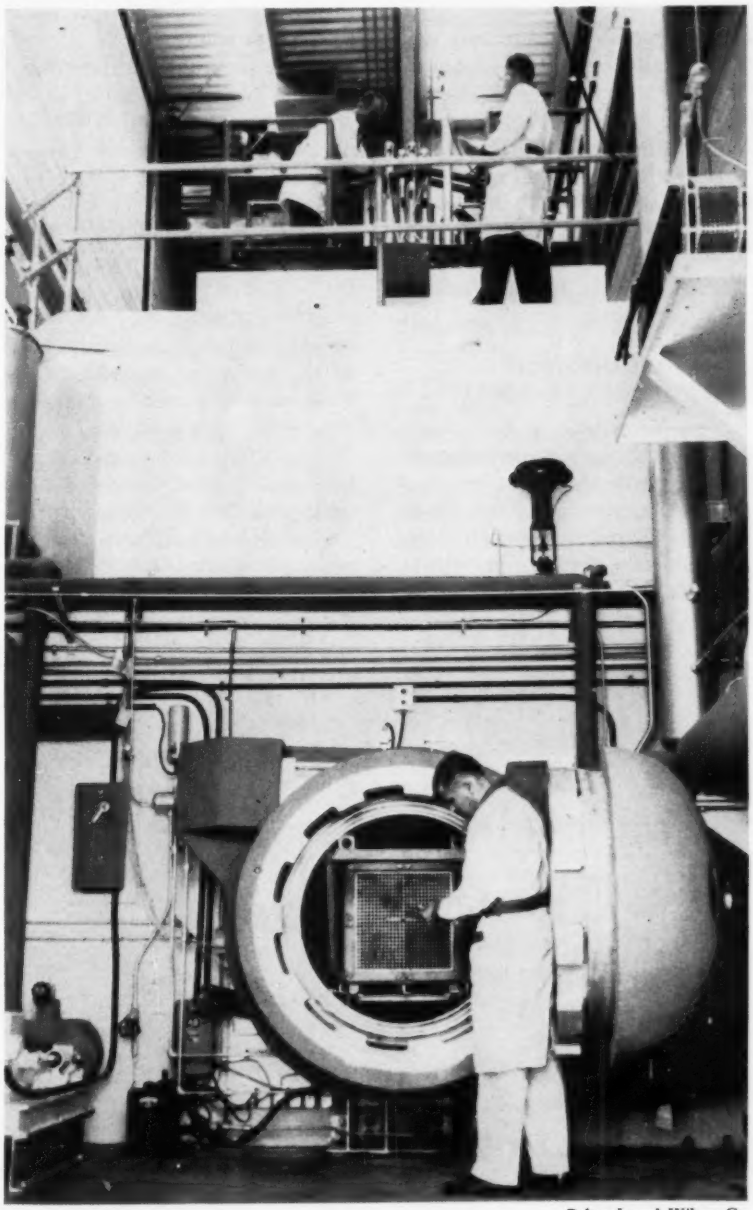
The research reactor will be operated at a nominal power of 10 KW. The reactor, however, is capable of powers up to approximately 200 KW. It will serve primarily as a neutron source for tests which will be conducted in the exponential facility. The reactor pool, essentially an open concrete shell seven by thirteen by eighteen feet, will be filled with highly purified, demineralized water. The reactor will also be employed for reactor physics experiments, neutron beam experiments, reactivity testing, and nuclear quality control of materials.

During test operations, a subcritical assembly of fuel rods is placed in the vessel, together with wires which record the neutron distribution along the axis of the fuel rods. The vessel is then filled with water. An external heater and pressurizer produce operating conditions up to 500 degrees Fahrenheit and 720 pounds per square inch of pressure. The adjacent reactor serves as a neutron source for the test assembly. A boral gate minimizes reactivity coupling between the reactor and the assembly under test.

After the wires have been exposed to neutron bombardment within the assembly, they are removed and their radioactivity is measured on the automatic scanning device to determine both the radial and longitudinal neutron flux distribution throughout the assembly. The neutron distribution is known to fall off exponentially along the axis of the assembly, giving rise to the name "exponential facility."

Believed to be the first commercial installation of its kind in the nuclear industry, a Teleflex wire activation system, based on a design by the Knolls Atomic Power Laboratory, is a vital part of the exponential facility. Neutron flux measurements at high temperatures and pressures are now possible without the requirement for first lowering the temperature or opening the exponential facility door to remove test material.

The Teleflex system consists of a drive mechanism which directs 8 dysprosium-aluminum wires, .020"



Babcock and Wilcox Co.

Operated in conjunction with the test reactor (near the top) the pressure vessel (near the bottom) permits evaluation of the life of nuclear reactor "fuels" under temperature and pressure conditions which duplicate those encountered in an operating reactor. Also built into the wall of the test reactor are other facilities which make it possible to irradiate many types of test specimens, and to conduct beams of neutrons outside for experimental and recording purposes.

in diameter and encased in hollow titanium flexible cables, into stainless steel conduits leading into the exponential facility.

Following a predetermined exposure to neutron bombardment from the reactor core, the cables are withdrawn and the exposed wires removed. The wires are then attached to a 27-inch diameter power-driven wheel or "scanning drum." An electronic timer rotates the aluminum drum and causes it to stop for a predetermined time for "counting" purposes. A scintillation detector measures the gamma radiation emitted by the wires. A digital printer translates the impulses either on tape or on an IBM card punch system. Reactor operating test conditions are thus automatically classified for subsequent analysis by B&W nuclear physicists with an electronic computer.

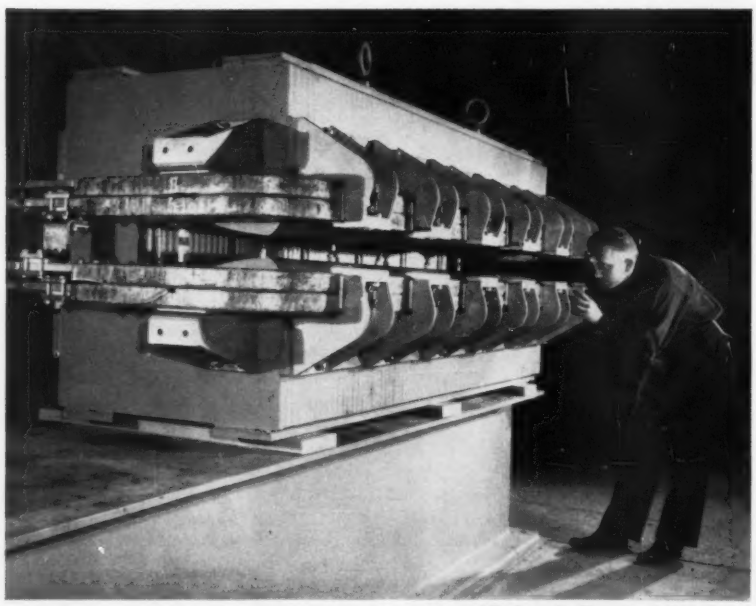
30 BEV SYNCHROTRON BEING CONSTRUCTED AT BROOKHAVEN

Now being built at Brookhaven National Laboratory on Long Island is the world's most powerful particle accelerator—a mammoth new proton synchrotron. The huge $25 million dollar machine will be ready for use about 1960. It will be capable of accelerating protons to energies of 25 to 30 billion electron volts. Russia now has a ten-billion volt synchrotron which began operation about a year ago.

The heart of the synchrotron will be a combination of 240 C-shaped magnets arranged in a circle more than a half mile in circumference. The magnets will be buried in an eighteen foot tunnel. Inside the large underground tunnel will be a smaller vacuum chamber in which the protons will travel.

Before a proton is introduced into the synchrotron itself, its energy will be raised to 750,000 electron volts in a high voltage generator. From there it will go to a linear accelerator which will raise its energy to 550 million electron volts. It will then be shot into the half-mile track where the giant magnets buried in the tunnels will serve to keep it in its circular path. As it goes around the path, twelve radio-frequency acceleration stations will give it additional energy so that after one second, it will have gone around the loop 350,000 times and have an energy of 25 to 30 billion electron volts. At this time, the proton will hit the nucleus of a target atom.

The new synchrotron will serve as a source of all types of subatomic particles and radiation and will be a powerful experimental tool to help further man's understanding of the nucleus of the atom.



Allegheny Ludlum Steel Corporation

This is one of the 240 giant magnets which will be used in the Brookhaven synchrotron. The magnetic force concentrated on these magnets makes it possible to hold charged particles exactly on their course while being accelerated.

BEAM OF LIGHT USED TO MEASURE MAGNETIC FIELDS

Two Commerce Department scientists have perfected a method of measuring magnetic forces. It is predicted that this development will provide scientists with magnetometers far more precise and compact than those now available.

Previous types of magnetometers have all been more or less unsatisfactory. The original system depended on the action of suspended magnets and was unsuitable for use in any moving vehicle. During World War II, an induction magnetometer was developed but it was rather unstable. The latest one, called a proton precision magnetometer has been used in some rockets and satellites but it fails in very weak magnetic fields.

In the new instrument, a beam of light is sent through a tube containing a small quantity of vaporized rubidium. The manner in which the light is absorbed indicates the strength of the magnetic field because the absorption of the light depends on the electron spin in the rubidium atoms, and the spin in turn is controlled by the magnetic field.

The extreme preciseness of the instrument and its compactness make it suitable for work in the laboratory and in geophysical prospecting for oil and metals. It will also probably find use in rockets and satellites. A rubidium detector may well be among the instruments in the first rocket to the moon. Scientists have long been seeking to discover whether the moon has a magnetic field. They do know that if it has one, it is extremely weak. Therefore, the rubidium detector with its extreme sensitivity would be the best instrument available for measuring the field.

Faculty Profile . . .

PROF. ARTHUR L. RUOFF

by

David S. Kessler, ME '62

Professor A L. Ruoff Epstein

Professor Arthur L. Ruoff, an affable crew-cut young man (he was recently 28), has been teaching at Cornell for three years. As an Associate Professor of Engineering Mechanics and Materials, Professor Ruoff teaches courses dealing with properties of materials.

Professor Ruoff was born in a small midwestern town (he was a Hoosier farmboy and is familiar with such things as cultivating corn and milking cows) in September, 1930. After graduating from high school he attended a two-year Purdue extension school near his home town. There he played on the varsity basketball and water polo squads. From the extension school he went to the main campus of Purdue and received a BS in 1952. He was the recipient, in 1952, of a Standard Research Fellowship, and he chose to use it at the University of Utah from which he received a PhD. in 1955.

Professor Ruoff, who is married and has three children, came to Cornell in 1955 and has been teaching courses dealing with mechanical properties such as creep, fracture, and elasticity. He has several pet philosophies on education. About the teaching of materials' courses he says, "The field of engineering materials should be viewed from a fundamental scientific viewpoint." Professor Ruoff said, concerning students, that he thinks we have many fine students although he is not always impressed by their performances. He believes the tendency toward laxity on the part of many students will change slowly. It is his feeling that a gradual tightening up of academic requirements will occur as a result of nationwide concern for education. "Perhaps my feeling in this matter is selfish," he said, "but if that is so, it is selfishness for the many good students who should not be mired in mediocrity."

Professor Ruoff told me that he is very pleased with Cornell, in general, since it gives him the things he likes most, namely an opportunity to teach, to do research, and to associate with people who think. He considers it all very stimulating.

Perhaps a keen insight into the personality of Professor Ruoff can be achieved from the cartoons and quips that adorn the walls of his office. One cartoon illustrates man's evolution, up hill, from the "slimy deep" to his present self and, then, man going, down hill, to the sea shore, putting on flippers and disappearing back into the deep. A current editorial quip reads, "No need to be too grateful to the scientists for showing us how to get to the moon. After all they're the ones who've made it necessary for us to evacuate the earth."

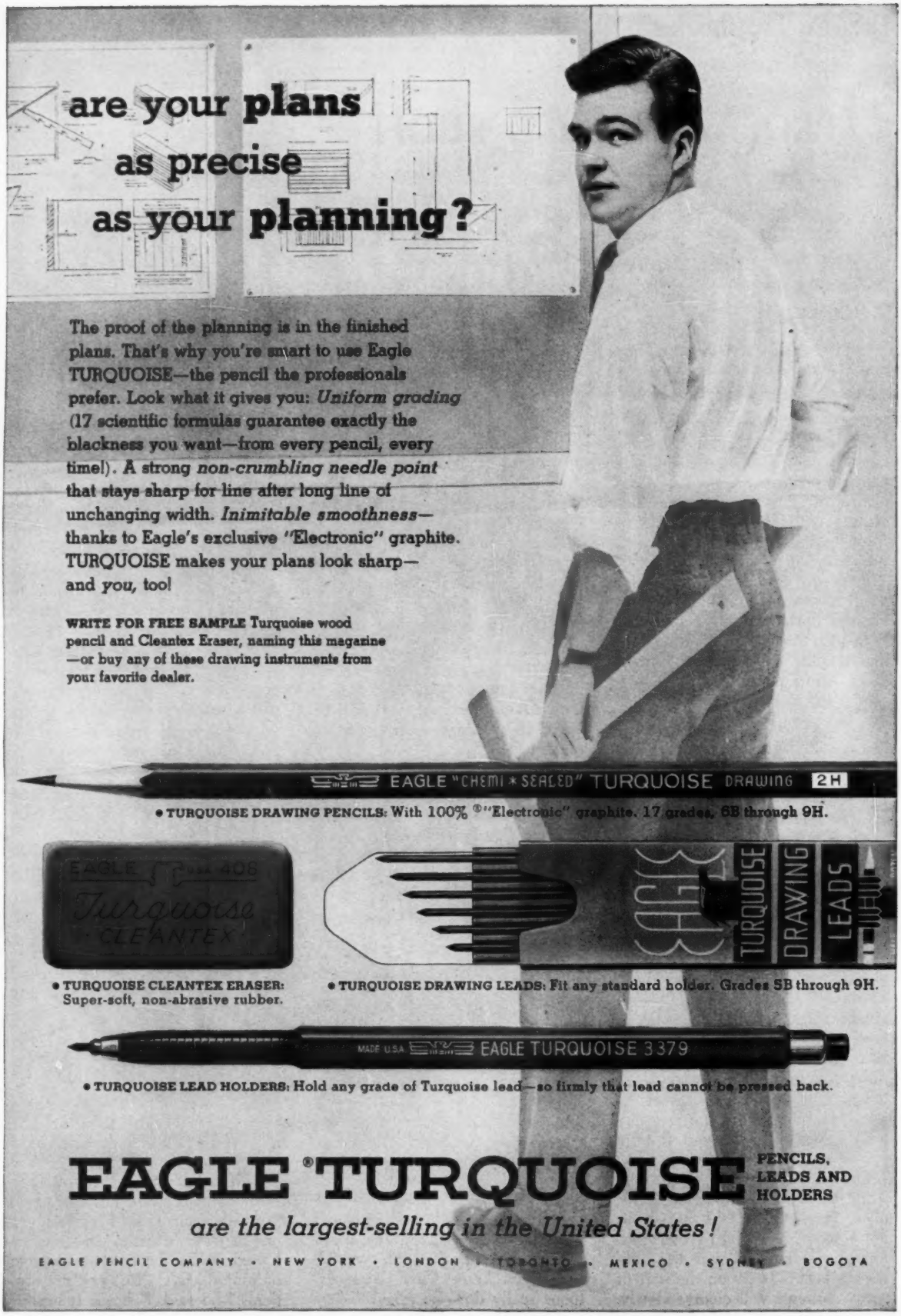
One might think that these cartoons and quips suggest a feeling of pessimism and even cynicism on his part. Prof. Ruoff offered to qualify this. After first stating that he feels sorry for anyone who does not have these qualities, he pointed out that it is really a matter of laughing, perhaps, at our own foibles. "You know what these cartoons really do?" he asked. "They calm what might be over enthusiastic optimism, since what I really feel is that we are slowly approaching a happier tomorrow. In the future, humanity will have sufficient faith in humanity to shape the universe to its own end."

Prof. Ruoff has worked on several projects in the short time he has been at Cornell. In a project sponsored by the Applied Physics Laboratory of Johns Hopkins University, he and Prof. Stewart worked on a method of rapidly loading structures. A cylinder-piston device, which uses an explosive, was employed to obtain square stress time impulses. Another research project concerned work on evaporative cooling. An evaporating or subliming compound was used to carry away heat developed in aerodynamic heating.

In regard to his studies of materials, they are directed to the end (1) that an understanding of basic atomic and microscopic processes are interesting in themselves; and (2) that such an understanding can lead to design of better materials or to better design with current materials.

In his free time Prof. Ruoff enjoys reading literature pertaining to the work he is engaged in and playing tennis. And, of course, he also enjoys being with his family.

Although modesty becomes Prof. Ruoff, he had no qualms about telling how difficult he likes to make his material courses. In fact, he hinted, he has become the scourge of junior ME's. "Just ask my students," he said. "They'll tell you."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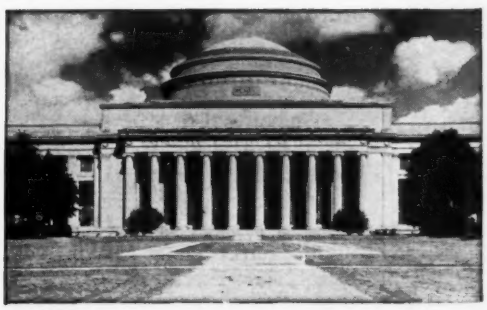

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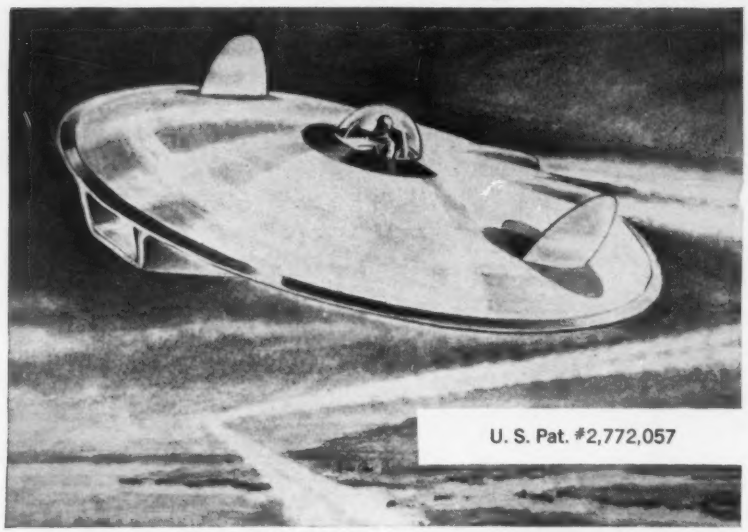

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ALUMNI ENGINEERS

(Continued from Page 35)

Reed Vail Bontecou, ME '25, has been appointed vice president—marketing of the electron tube and semi-conductor division of the Columbia Broadcasting System, Inc. Previously, he had been manager of marketing for the receiving tube department of the General Electric Company.

During the fifteen years he was with the tube division of General Electric, Mr. Bontecou rose from manager of standardizing, engineering department, to his present position. He served in the sales department as market analyst, staff assistant to the manager, manager of market research, and manager of marketing research and product planning. In 1953, he was made product manager and was elevated to manager of marketing a year later.

John W. Weigt, ME and EE '18, New York branch sales manager of Exide Industrial Division, The Electric Storage Battery Company, retired July 31 after more than 38 years' service with the Philadelphia firm.

Personnel of the New York branch honored Weigt on July 28 at a dinner in New York, and on the following day, Exide Philadelphia headquarters officials gave a luncheon for him in Philadelphia.

For the past 12 years, Weigt has been in charge of Exide Industrial battery sales and service in the New York State, northern New Jersey and western Connecticut area, with headquarters at 25 West 43rd Street, New York.

Prior to joining Exide, Weigt was employed briefly as an assistant engineer at John Thompson Press Co.

During World War I, Weigt served as an instructor in the U. S. Army Signal Corps officers training battalion at Camp Alfred Vail, Little Silver, N. J. He was a second lieutenant.

Weigt is a past national president and a member of the Society of Terminal Engineers, and a life member of the American Institute of Electrical Engineers. He also is a past national president and a member of Eta Kappa Nu, honor-

ary electrical engineering fraternity. For several years, he was editor of *The Bridge*, Eta Kappa Nu publication.

Weigt also is a member of The Newcomen Society of England in North America and of the American Legion.

THE ORIGIN OF ZERO

(Continued from Page 17)

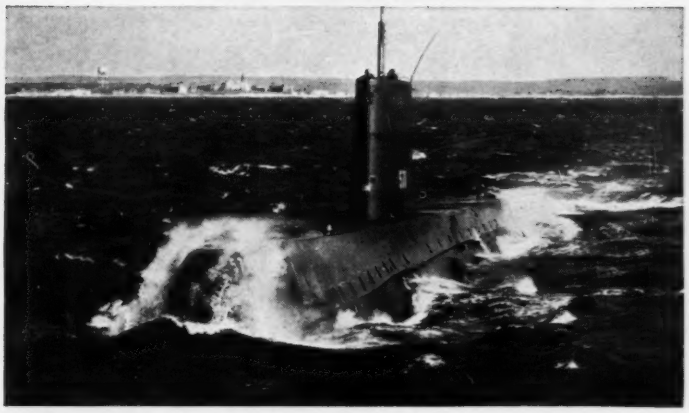
Thus as mathematics began to emerge as a study in itself, the Hindus had already established a tradition of intellectual inquiry and attainment in cultivated science, art, religion and philosophy. Without the adoption of ganita as a cultural study, the mathematics which emerged from the sand strewn counting table would have been just a place-value notation, differing from that of the Sumerians' by only a six-fold decrease in base and a more standard use of zeros to fix the absolute value of a number.

By continued and systematic analysis of the calculation process in the course of the following centuries, however, the Hindus extracted its essential concepts and crystallized these as comprehensive symbolic formuli or equations. From these basic axioms, a powerful symbolic algebra developed which could not only solve practical problems through flexible generalized methods, but also provide satisfying assurance of the accuracy of the solutions through logically consistent deductive proofs.

With the study of the basic concepts of arithmetic in India came a critical examination of zero and its eventual conception as an infinitesimal. This final phase in the development of the concept of zero had essentially no effect upon its use in place-value notation. For that, the Sumerian "blank-space indicator" concept is perfectly adequate.

For the development of higher mathematics, however, the Hindu sophistication of the concept of zero has had penetrating consequences in the notions of convergence, limits, continuity and other aspects of the calculus. By thus developing a concept of zero to suit their own needs, attitudes and ingenuity, our various ancestors have made valuable contributions to mathematics over a wide plane.

Project $914-7



WESTINGHOUSE DESIGNED REACTOR ON FIRST ATOMIC SUB MAKES NUCLEAR NAVY INEVITABLE

A few pounds of uranium in the *Nautilus* did the work of 3,000,000 gallons of fuel oil. Westinghouse designed and developed the *Nautilus* reactor under the direction of and in technical cooperation with the Naval Reactors Branch of the U.S. Atomic Energy Commission, and is now developing reactors for large surface vessels and more submarines to give the U.S. Navy the world's first atomic fleet.

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Project W873-5

WESTINGHOUSE DEVELOPS NEW SOURCE OF LIGHT... RAYESCENT* LAMPS

Light in any color flows from wafer-thin panels of glass without the use of bulbs, tubes or fixtures in a new type of light developed by Westinghouse. This picture shows the first room ever illuminated by this RAYESCENT system. Dr. E. G. F. Arnott, Research Director of Westinghouse Lamp Division, holds one of the new RAYESCENT lamps now being marketed.

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Project R501-6

WESTINGHOUSE DEVELOPS MOBILE RADAR TO PROTECT FRONT LINE TROOPS

Inside this inflated balloon-like housing is a full-size transportable radar station that can be brought up behind front lines or dropped by parachute. It can be erected in less than two hours. Its antenna is of inflated fiberglass cloth that looks like a giant lollipop. Major General Stuart P. Wright of the ARDC's Rome Air Development Center which sponsored this development, says this is "a major break-through in ground electronic equipment."

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Project W545-8

WESTINGHOUSE DEVELOPS NEW METALS TO HELP CRACK HEAT BARRIER IN JET ENGINES

Tremendous temperatures encountered in jet engines cause loss in mechanical strength of engine parts. Westinghouse scientists are developing new high-strength, high-temperature metals designed to push back this "heat barrier." These new alloys may add 100 mph to a jet's top speed.

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WATER FOR ANCIENT ROME

(Continued from Page 25)

and flows into a reservoir after a short run yields a surplus. Whenever it comes from a lower point under less pressure and a longer distance it shrinks in volume owing to the resistance of the conduit."

In order to account for these variables in flow, a calix, which is a bronze ajutage, was inserted into a conduit or reservoir, and to it the service pipes were attached. The calix, which was not to have a length less than twelve digits, was a vane whose angle of inclination varied according to the velocity of flow and either restricted or permitted the water to pass. This way a reasonably steady flow in the pipes could be maintained.

When Frontinus became Water Commissioner of Rome, one of his first undertakings was to check the amount of water supplied to the city against the amount received and paid for. He found, according to his gauges, that the total volume of water supplied by all of the aqueducts at the intakes was approximately 24,000 quinariae. Of this total supply only 12,755 quinariae was reported as delivered. Frontinus knew that a good deal of leakage took place along the conduit, but the major portion of the discrepancy he attributed to illegal tapping of the water supply and dishonest reports of quantities received. As a result he undertook a major shakeup, so to speak, in the personnel of the water department.

Unquestionably, dishonesty did exist within the water department and outside of it, but what is questionable is the reliability of Frontinus' flow measurements. Charles Bennett who translated Frontinus points this out quite clearly, "The most troublesome point of ignorance which Frontinus had to contend was a total inability to measure the velocity of water or even rightly to grasp fully the idea of such velocity, whether in open channels or closed pipes. He compares streams of water merely by the area of their cross sections, and then worries himself into all sorts of explanations as to why his gaugings by areas made irrespective of heads and velocities, do not balance." However, Frontinus was

able to increase considerably the existing supply by reclaiming unlawful supplies.

One of the commentaries on the improved situation was, "Not even the waste water is lost. The appearance of the city is clean and altered; the air is purer and the causes of the unwholesome atmosphere which gave the air of the city so bad a name with the ancients are now removed."

The organization of the Water Department in Rome was quite similar to that found in any modern day municipality involved with a large water supply system. The primary duty of the Water Commissioner was to enforce the pertinent laws and Senate enactments.

The maintenance of the aqueducts was undertaken by two separate organizations. One was a state gang composed of 240 men. The other was called Caesar's gang, having more than 400 men and originally supported from the Emperor's own coffers. These maintenance crews consisted of overseers, reservoir keepers, inspectors, pavers, plasterers, and common laborers. The state gang was supported by the state treasury. Certain repairs of the aqueducts were regularly let out to private contractors. The prinicipal causes of damage to the conduits were lawlessness of abutting proprietors, the effects of age, violent storms, and defects in original construction. Repairs which necessitated a break in the water supply were made at a time of lowest demand if at all possible.

The water supply system for the city of Rome typifies the nature of Roman engineering achievements. They seem to have an uncanny insight into the solution of problems with no concern for a rigorous proof. This is in comple opposition to the nature of the Greeks where practical applications lagged scientific progress. Thus as a result of their nature the Romans achieved a material standard not to be equalled for many centuries to come.

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Project S333-9

WESTINGHOUSE DESIGNING NUCLEAR REACTOR THAT WILL MAKE ITS OWN FUEL

Westinghouse and the Pennsylvania Power & Light Company are jointly developing the engineering information required to design and operate a "homogeneous" nuclear reactor plant for the generation of electricity. If successful, the companies anticipate the reactor will largely fuel itself by converting thorium into fissionable fuel after an initial charge of enriched uranium. Dr. W. E. Johnson, manager of the project, studies a transparent model of the reactor vessel.

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Project R246-7

NIGHT-FLYING PILOTS SEE GROUND WITH DAYLIGHT BRIGHTNESS ON SUPER-TV PERFECTED BY WESTINGHOUSE

The "Cateye" system is so sensitive that it will work with less than one millionth of the illumination used in the television studio. It will make night flying safer for pilots and passengers. This remarkable image intensifier was conceived by the Aeronautics Research Laboratories of the Wright Air Development Center . . . and Westinghouse was asked to perfect it.

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Project B463-3

WESTINGHOUSE OPERATES "FLYING LABORATORIES" TO DEVELOP ELECTRONIC EQUIPMENT FOR THE ARMED FORCES

More than 1,100 in-flight hours were logged in 1957 by the Westinghouse Air Arm Division Flight Test Center in the development of military airborne electronic systems. To carry out the numerous flight development programs, the Air Arm Division employs 35 professional personnel, including five engineering pilots, and 55 technicians.

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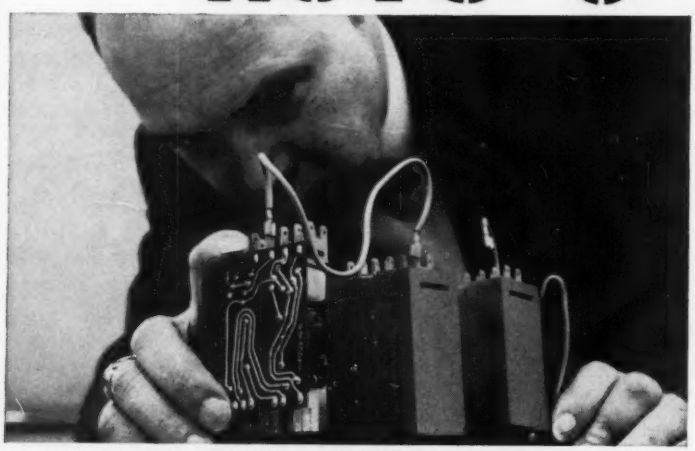
Project R378-5



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4) Van Deman E. B.: *The Building of the Roman Aqueducts,* Pub. Carnegie Institute of Washington, 1934, pp. 67–139.

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ANALYSIS ENGINEERING

(Continued from Page 28)

name. This is only a problem with the standard FUR machine cards because these contain only a part number.

Following assignment of part numbers, etc., the trouble reports are processed. In the processing of FUR's a new card, containing only information of interest to the manufacturer, is first punched out. Following this step the FUR is processed as shown in the diagram.

The processing of AMPFUR's is a longer procedure. The report is received as two machine cards; a statistical card similar to a FUR, and an aperture card containing a microfilm photograph of the original report. As soon as the aperture cards are received, they are screened to determine which cards should be brought to the attention of the engineering department for investigation. Usually, all cards which contain significant or consequential information are presumed to require investigation. Microfilm prints are routed to project engineers, while the analysis engineering department receives the aperture cards. Since an AMPFUR relates a condition which cannot be described by a simple check off list, a "phrase" for each report has to be prepared. The "phrase" gives a brief description of the trouble and its cause. It is also forwarded to interested engineering departments. The processing of electronic failure reports is almost identical with that of AMPFUR's.

Calculation of Failure Rates

In order to perform reliability studies, failure rates must be evaluated as previously mentioned. The trouble reports just mentioned are immense aids in facilitating the compiling of information for such studies.

Failure rates are discrete numbers which are normally computed to prove a point in some very specific situation. Many of the components involved are designed or modified for a particular application. Because components are not mass produced and because units have long service lives, failure data are scarce. Consequently, to compute failure rates for a wide range of reliability studies, it is necessary to have failure histories readily available so that any desired specific information can be readily extracted.

Failure histories consist of printed IBM runoffs of the failure cards for selected account numbers. They are prepared upon the request of the engineering department when that department wants to establish or confirm operational requirements for the design of similar components or systems.

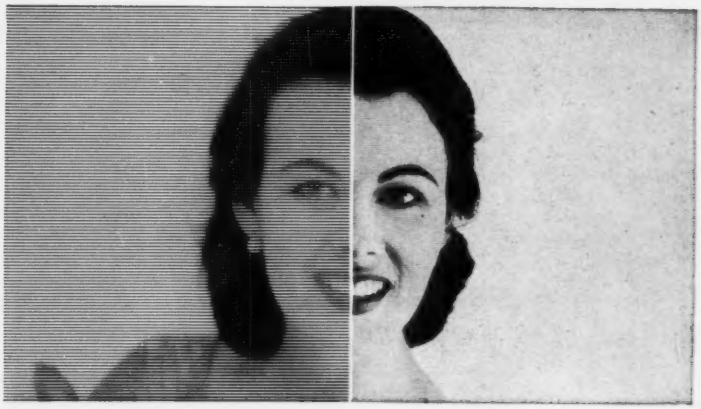
Although the information gathered from trouble reports is used primarily by the analysis group for reliability studies, the material is used for a number of other purposes such as development of improved component design criteria (again the analysis group) and the evaluation of maintenance and availability characteristics of aeronautical equipment under actual service conditions.

One of the new problems that analysis engineers are preparing to meet is that of system potential. The idea is that a system must be designed so that it has a certain basic potential. With the armed services turning to a weapons system controlled by management, a typical problem facing engineers might be: The enemy will employ certain tactics. What weapons do we need to deploy these tactics?

A look into the future reveals that there will be a great need for analysis engineers. The analysis engineering department, taking advantage of modern means of communication and exploiting the engineer who can analyze and think well, is preparing to meet challenges that lie ahead.

The author wishes to acknowledge the assistance of Mr. John de S. Coutinho and Mr. Alonzo Gibbs, both of the Grumman Aircraft Engineering Corporation, without whose assistance this article wouldn't have been possible. Mr. Coutinho is the group leader of Grumman's Analysis Group.

Project $728-6



WESTINGHOUSE RESEARCH WILL LEAD TO LARGER, CLEARER TV SCREENS

Big TV screens magnify distracting black and white horizontal lines. Westinghouse engineers have developed a new technique to reduce the black lines and clarify white lines which give picture information. When available, the new process will make possible bigger TV screens, more and clearer picture detail.

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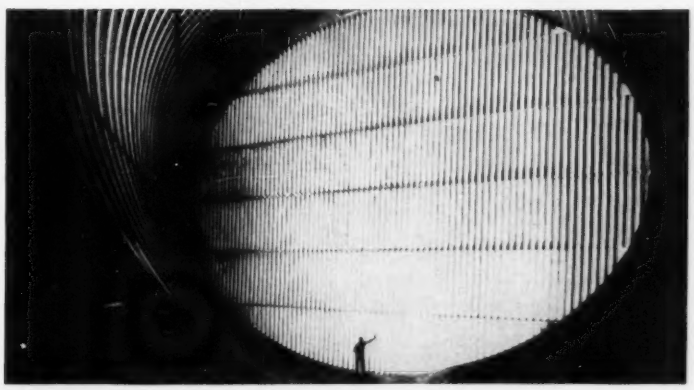
Project $112-2



WESTINGHOUSE DESIGNED MOTORS AND COMPRESSORS FOR WORLD'S MOST POWERFUL WIND TUNNEL

This propulsion wind tunnel will test jet engines, aircraft and guided missiles in winds up to 38 times hurricane force. Largest of its type ever built, it is located at the U.S. Air Force Arnold Engineering Development Center,* Tullahoma, Tennessee. The synchronous motors and compressors that produce this gigantic air flow are the largest in the world . . . designed and built by Westinghouse.

*U.S.A.F. Air Research & Development Command

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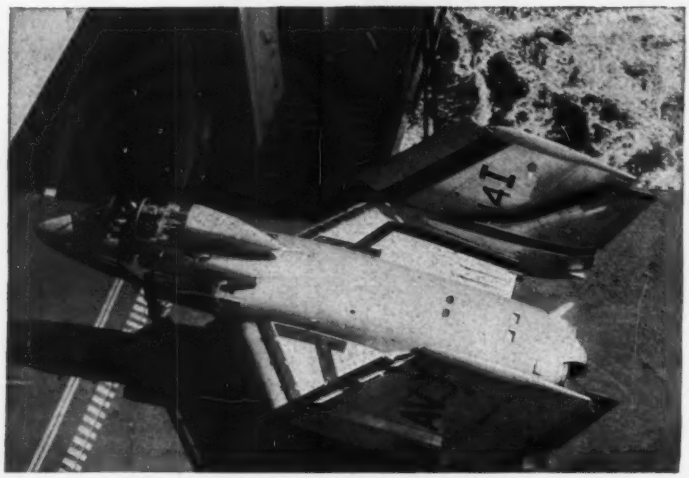
Project W428-3



WESTINGHOUSE BUILT WORLD'S LARGEST ELEVATORS

The *U.S.S. Forrestal's* four deck-edge elevators can deliver four 70,000-lb. jet bombers from hangar deck to flight deck in seconds . . . smoothly without even a jar. Deck-edge elevators were pioneered by Westinghouse.

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Project B517-8

WESTINGHOUSE BUILDS BOMBER DEFENSE SYSTEM THAT CAN SELECT MOST DANGEROUS ATTACKER, AIM AND FIRE AUTOMATICALLY

Two tail guns controlled by a Westinghouse developed electronic system make up the defensive armament of the Navy's A3D. A radar scanner spots the most dangerous attacking aircraft. A computer determines its speed and angle of approach . . . then aims the guns and signals the gunner to fire or it fires automatically. The guns then instantly swing to the next target.

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COLLEGE NEWS

(Continued from Page 39)

serves in this country. It is estimated that it would take this country 300 years, at the present rate of consumption, to use up the oil which is now locked in the shale rock of the three Western states. It is expected that oil will be produced from these reserves within a few years, and that by 1975, the industry will be producing nearly 1,000,000 barrels a day.

The city which the Cornell students will design is to be built in the valley of the Colorado River between Silt and DeBeque. The area of the shale oil development of the proposed city is located in Garfield County. It will be a modern city in every respect, with little semblance to the cities of the past. Because the extraction plants and refineries will be constructed outside the community and in the canyons, the city will be singularly free from "industrial blight."

The city-planning project at Cornell will be sponsored by the Shale Oil Development Committee of the Colorado State Chamber of Commerce.

CORNELL COUNCIL DISCUSSES SCIENCE EDUCATION ON CAMPUS

The eighth annual meeting of the Cornell Council was held October 3–5. The meeting concerned science education at Cornell.

Among the speakers were Marion B. Folsom, former United States Secretary of Health, Education, and Welfare, who spoke on federal aid to education. He remarked that it was an "exaggerated fear" to think that federal aid meant federal control. Also speaking were Professors M. J. Sienko of the Chemistry Department and Hans A. Bethe of the Physics Department, both of whom praised Cornell science. Prof. Sienko emphasized the crowded condition of Cornell lectures and laboratories, and the over-dependence on teaching assistants.

There was a panel discussion on "Problems of Scientific Leadership in the Twentieth Century" with Prof's D. R. Corson (Physics), F. A. Long (Chem.), J. B. Rosser (Math), A. R. Srb, (Plant Breeding), and W. A. Wimsatt (Zoology). Lectures presented were:

"Mirrors, Magnets, and Matter," Prof. Phillip Morrison; "Chemistry of Blood Clotting," Prof. Harold Scheraga; "Non-nuclear News from Bikini," Prof. John Wells; and "Population Biology," Prof. L. Cole.

The closing dinner included a program by the Cornell Men's Glee Club.

NEW MOLECULE BEING CREATED WITH VAST FUTURE USES

A new kind of molecule is being developed by two Cornell University chemists which may help fly jet planes or contribute to the cure of cancer.

If they succeed, the researchers will have solved a classical problem in organic chemistry.

Prof. Alfred T. Blomquist and Mrs. Yvonne C. Meinwald are trying to create new ring-shaped molecules out of four atoms. Most such molecules have five or six atoms. Professor Blomquist and Mrs. Meinwald, a Cornell Research Associate, have been working on the problem for about two years.

The Cornell chemists have two immediate objectives. These include, first, the creation of certain small organic high-energy molecules which have never been observed in nature; and, second, the study of how these substances behave. Such an investigation should give scientists greater understanding of the atomic forces at work in carbon compounds.

Solution of the problem could mean the development of new plastics, fibers, drugs, and dyes. The researchers say, however, that they cannot foresee all the details of the technological improvements which may come out of their work.

"This is the sort of exploratory research from which a great many things could develop," Professor Blomquist states. "We are following many trails. Where they go no one knows, but they could lead to exciting things."

Professor Blomquist says the ultimate results might include anything from new drugs to revolutionary textiles.

"Because of our work, researchers in other fields might encounter substances which would prove effective against cancer. They may find a drug which will react with cancer cells rather than with normal cells without killing the host."

WESTINGHOUSE IS THE BEST PLACE FOR TALENTED ENGINEERS

There's a wide variety of engineering and scientific work for the able engineer at Westinghouse. The brief stories told in the preceding advertisements only scratch the surface. A hundred or more other activities, each as interesting, also demand the services of really talented engineers. This *diversity of opportunity* is one of the biggest reasons for choosing Westinghouse.

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Incoming college graduates are enrolled in the Student Training Course, a well-integrated program providing assignments in many operating divisions; each man finds the type of work best suited for him. Thereafter, the opportunities for further study are dependent upon the kind of career you want.

For those desiring a TECHNICAL career:

GRADUATE STUDY PROGRAM—For graduates of engineering or the physical sciences, Westinghouse offers a Graduate Study program leading to M.S. or Ph. D. degrees. This plan offers the qualified individual an opportunity to pursue further graduate work in conjunction with his regular job.

ADVANCED DESIGN COURSE—This full-time four-month Westinghouse program, held at the University of Pittsburgh, is offered to selected engineering and physical science graduates who demonstrate unusual aptitude in research, design, or development work.

ADVANCED MECHANICS PROGRAM—For selected mechanical engineers, Westinghouse, each year, offers a full-time fifteen-month graduate program in advanced mechanics at the Research Laboratory in Pittsburgh. Classroom work is held at the University of Pittsburgh, and all of it is creditable toward an M.S. degree.

HONORS GRADUATE PROGRAM—For a limited number of selected men, Westinghouse has a released-time graduate study program aimed at the fulfillment of requirements for Ph. D. degrees.

B. G. LAMME FELLOWSHIPS—Based upon a yearly competition among outstanding men who are under 35 but who have been with the Corporation at least five years, Westinghouse awards B. G. Lamme Fellowships for one year's full-time graduate work on stipend and salary allowance with all tuition and transportation expenses paid.

For those desiring a MANAGEMENT career:

BUSINESS & MANAGEMENT PROGRAMS—These are programs of business courses at nine different universities for mature men in business, particularly graduates in engineering and the sciences, who have not majored in business administration.

MANAGEMENT DEVELOPMENT PROGRAM—This program provides position rotation for more breadth of experience, participation in advanced management schools for more senior professional employees, and in-company specialized courses for the development of executive talents.

If you're interested in more information about these programs at Westinghouse, write to Mr. L. H. Noggle, Westinghouse Educational Department, Ardmore and Brinton Roads, Pittsburgh 21, Pa.

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Professor Blomquist suggests, too, the possible development of synthetic rubber which will withstand extreme heat. Such a product, he says, would be useful in jet aircraft.

"A long-range goal of scientists working with synthetics is to find a synthetic rubber-like ceramic which will withstand red heat," Professor Blomquist says.

The research is supported by a National Science Foundation grant of $28,500.

NBC AND CORNELL TO GIVE TV CREDIT COURSE IN PHYSICS

Cornell University announces participation in a project of education by television sponsored by the National Broadcasting Co. Cornell is one of an anticipated 200 or more colleges in the nation which will be offering college credit for a course identified as Physics for the Atomic Age.

The course began Monday, Oct. 6, with a daily televised broadcast, Monday through Friday of each week from 6:30 to 7 a.m. Demonstrations and experiments are shown and explained during the half hour periods. These presentations are supplemented by carefully selected tests, additional readings and other out-of-class activities. The course will continue throughout the academic year of two semesters and provides three hours of college credit per term for a total of six credits. At Cornell this credit will be the equivalent of its regular six hour General Physics course.

This new venture in education through the medium of television is designed primarily for high school teachers of Science but may be taken by any person desiring upper level, undergraduate and graduate, credit. The teaching is done by Dr. Harvey E. White, professor and vice-chairman of the Department of Physics at the University of California, and by other internationally known scientists. The instructional staff has at its disposal the advice and consultation of leading members of the American Institute of Physics.

Cornell's participation in this program is under the jurisdiction of the Division of Summer Session and Extramural Courses in cooperation with the Department of Physics. Prof. J. W. DeWire of the physics department is serving as local coordinator and adviser to students.

ENGINEERING PROFESSORS ENGAGE IN VARIED ACTIVITIES

Chemical Engineering

Prof. R. G. Thorpe is on sabbatical leave for the fall term.

Assoc. Prof. Ferdnand Rodrigez, who received his PhD. at Cornell, will be teaching here this year.

Civil Engineering

Assoc. Prof. William L. Richards, who has previously been an assistant professor at Pennsylvania State University for four years, will be teaching in the department of Administrative Engineering.

Dr. Mohamed M. Tewfik, a visiting professor from the University of Cairo, Egypt, will assist in the soil mechanics department and pursue his own studies with concrete. Dr. Tewfik holds a doctorate from Cornell.

Dr. Mahmoud S. Amin, also a professor at the University of Cairo, will be here for one year to study hydraulics. Dr. Amin has previously studied at Colorado State University.

Dr. Henry J. Hopkins, professor from the National School of Engineering, University of Canterbury, Christchurch, New Zealand, will be working here this year. He is to prepare a history of structural engineering, and will work with Dean Hollister and Prof. Winter of the CE school.

Electrical Engineering

Prof. J. L. Rossen will be working to prepare a 300,000v underground electrical cable (see Apr. 1958) for use during the fall term. He will not be teaching this term.

Assoc. Prof. Hugo Messerle, of the University of Sydney, Sydney, Australia, is here on a Fulbright Travel Grant to work with special control circuits.

Prof. Norman Vrana has taken a sabbatic leave to work with North American Aviation in their Aeronautics Division for one year.

Engineering Physics

Prof. T. N. Rhodin is a new professor who will be a principal investigator of a naval research project. (See above).

Mechanical Engineering

Assoc. Prof. R. E. McGarrah has resigned and is now teaching at the Harvard Graduate School of Business.

Prof. Robert E. Bechhofer has taken a sabbatical leave to work at Stanford University, Palo Alto, California. He will be continuing his work on Statistical Multiple Decision.

Mechanics and Materials

Prof. E. T. Cranch is on sabbatic leave for this year. He will be associated with Stanford University's mechanics division as an independent research worker. He was awarded a National Science Foundation Science Faculty Fellowship.

Prof. H. D. Conway is at Ohio State University on a Stone Visiting Professorship.

ARCHITECTS' SUMMER PROJECT TO REVOLUTIONIZE THE CIRCUS

According to Prof. Henry Elder of the College of Architecture, modern buildings would give the circus industry a much-needed shot in the arm.

He was supported by Prof. F. M. Wells, co-director with Professor Elder, who stressed the artistic needs of circus architecture. "The circus is dying, and its art form is decadent," Professor Wells stated. "By revitalizing the art form we could revitalize the environment in which the industry might again flourish."

With their 20 students, Professors Elder and Wells sought to do just that. Working during the 10-week 1958 Summer Session, the students made an intensive study of circus history beginning back in Roman times. They heard lectures by specialists in various fields related to circus entertainment. Then they built models showing how they thought a circus' winter quarters in Florida should look.

They designed broad, curving walks, terraced pools, and ultra-modern cages for animals. They included living quarters for roustabouts, administration buildings, and refreshment stands. One model showed a circular staircase descending into the depths of an aquarium.

"We wouldn't want to give circus-goers the feeling of walking

through an art gallery," Professor Elder said. "The smell of the animals is an essential part of it. On the other hand, we do think most circus grounds could use an overhauling."

CORNELL SCIENTISTS DESIGN HUGE RADAR TO PROBE SPACE

A radar the size of two football stadiums is being designed by Cornell University scientists.

It will be used to probe outer space, to gain information which may aid man in becoming a space traveler.

The monster detector was proposed at a conference on space radar held here Wednesday. Cornell physicists and engineers traded ideas with representatives of the Army, Navy, and Air Force.

Two sites are being considered for the huge scanner. One is a limestone sink in Puerto Rico. The other is a similar formation in Texas.

The 1,000 foot dish will sound out mysteries of space which once seemed accessible only to artificial satellites. Although it will not substitute for satellites, it will free satellites for other work. It will also relay information about electron density and temperature much more quickly and economically than satellites.

The device will probe the thick cloud cover around Venus, giving scientists a better picture of its surface, shape and distance from the earth. It will also provide information about Mars and the sun.

The project was sparked by Dr. William Gordon's recent discovery that electrons in outer space could be detected with extremely powerful radar units. Dr. Gordon, Associate Professor of Electrical Engineering Research at Cornell, says electrons higher than 60 miles above the earth scatter radar waves so weakly that they have not been seriously considered by most scientists.

"Calculations show that this incoherent scattering, while weak, is detectable with powerful radar," Dr. Gordon states.

The radar will give scientists a knowledge of sub-atomic matter in outer space which will bring man closer to actual space travel. It may also provide new clues about the weather.

Dr. Gordon says the radar should be completed about a year and a half from the date money is granted for the project.

"We hope to have it completed with all the flaws out by April, 1961, because that's when Venus will be closest to the earth," the scientist says.

ADDITIONAL DEAN'S LIST 1957–1958

School of Chemical Engineering

Martin Prager, George Willard Roberts, Enrico Sismondo, Peter Reeves Sperry, Roger Carl West.

School of Mechanical Engineering

Eugene Leonard Appel, James Stephen Bethea Jr., Saul Blumenthal, Richard George Brandenburg, Robert Codner Carlson, Garrett Rix Codrington, Alan James Dybvig, Clifton Vedantus Edwards, Gerald Barker Gilbert, Richard Mitsugu Hamoda, Herbert Peter Hess, Robert Ferrand Hinman, Edward Joel Ignall, Timothy Joseph Keliher, Thomas Brazell Kempster, David Steven Kessler, Alan Lippert, Bruce David Marcus, Peter Carl Meinig, Norman Calvin Miller, Herbert Mittleman, Paul Julian Mode Jr., Richard Douglas Nelson, Martin Edward Ness, Robert Christian Pfahl Jr., James G. Rae, Roger Winston Robinson, Robert Shaw Jr., Gerald Robert Spielvogel, John Arthur Swanson, Robert Scott Teich, Julius Frederick Weinhold Jr., John Robert Wolberg, Gerold Yonas.

Department of Engineering Physics

Ralph Ludwig Bayrer, Richard Eugene Berent, Oscar M. Browne III, Daniel T. Christianson, William W. Cooper, Gary Kenneth Cowell, William T. Dixon, George Samuel Downs, Julius Feinleib, William Albert Friedman, Peter M. Goldreich, Bryan F. Gore, Michael George Hauser, Lawrence S. Iwan, Allan Shale Krass, Kenneth Mark Lipman, Edward Powell Loane, Ben Edward Lynch, Lloyd D. Malmstrom, Francis Landis Markley, Peter H. Mengert, Carl J. Modig, Park S. Nobel, Thomas D. Parrish, Edward Ernest Pilat, Douglas Arthur Pinnow, Stephen Michael Pollock, Harvey S. Price, Alan W. Riddiford, William Ronald Roach, Gerald Schubert, Henry J. Scudder III, Donald M. Spero, Joseph F. Terdiman, Robert E. L. Turner, Robert W. Weinman, Theodore Alexander Wilson, Richard Alan Wolf, Benjamin Weston Woodward, Philip Robert Yarnell.

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(Consultant engineer in the field of work simplification)

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New York City

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- Dinner, 6:30
- Meeting, 8:00

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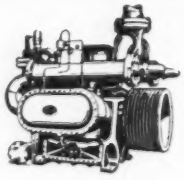
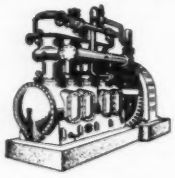


ECLIPSE COMPRESSORS



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Number the picture captions!

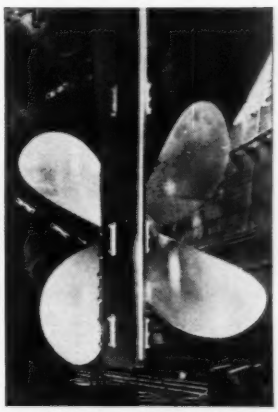
1. Nickel cast iron
2. Chromium-nickel stainless steel
3. 4340 constructional alloy steel
4. Ductile Ni-Resist*
5. Cupro-nickel
6. Nickel-aluminum bronze
7. Ni-Resist nickel cast iron

*Registered trademark

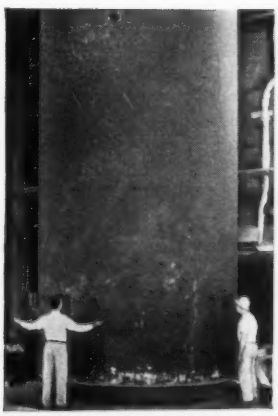
See answers below

☐ **Piston ring carrier insert**—Needed: wear resistance, thermal expansion to match aluminum. Which alloy?

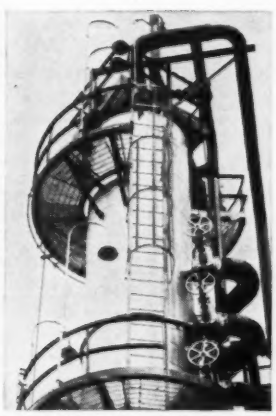
☐ **Grader drive axle**—Needed: toughness, impact resistance, greatest strength, with least weight. Which alloy?



☐ **Ship's propeller** — Needed: light weight, high resistance to erosion, sea water corrosion. Which alloy?

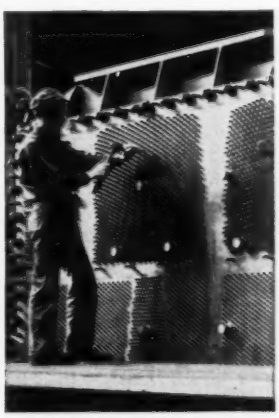


☐ **Yankee dryer roll** — Needed: high strength, uniform structure in cross sections of heavy castings. Which alloy?



☐ **Catalytic polymerization tower** — Needed: resistance to phosphoric acid at 375°F, 500 psi. Which alloy?

☐ **Turbocharger housing** — Needed: resistance to thermal shock, heat, corrosion at 1500°F. Which alloy?



☐ **High pressure marine condenser** — Needed: heat transfer, stress, corrosion resistance. Which alloy?

You may have to take this kind of quiz *again*. You may be designing a machine which requires a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

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answers

- Piston ring carrier insert.....7 Ni-Resist
- Grader drive axle.....3 4340 constructional alloy steel
- Ship's propeller..6 Nickel-aluminum bronze
- Yankee dryer roll.....1 Nickel cast iron
- Catalytic polymerization tower.....2 Cr-Ni Stainless
- Turbocharger housing..4 Ductile Ni-Resist
- High pressure marine condenser.....5 Cupro-nickel

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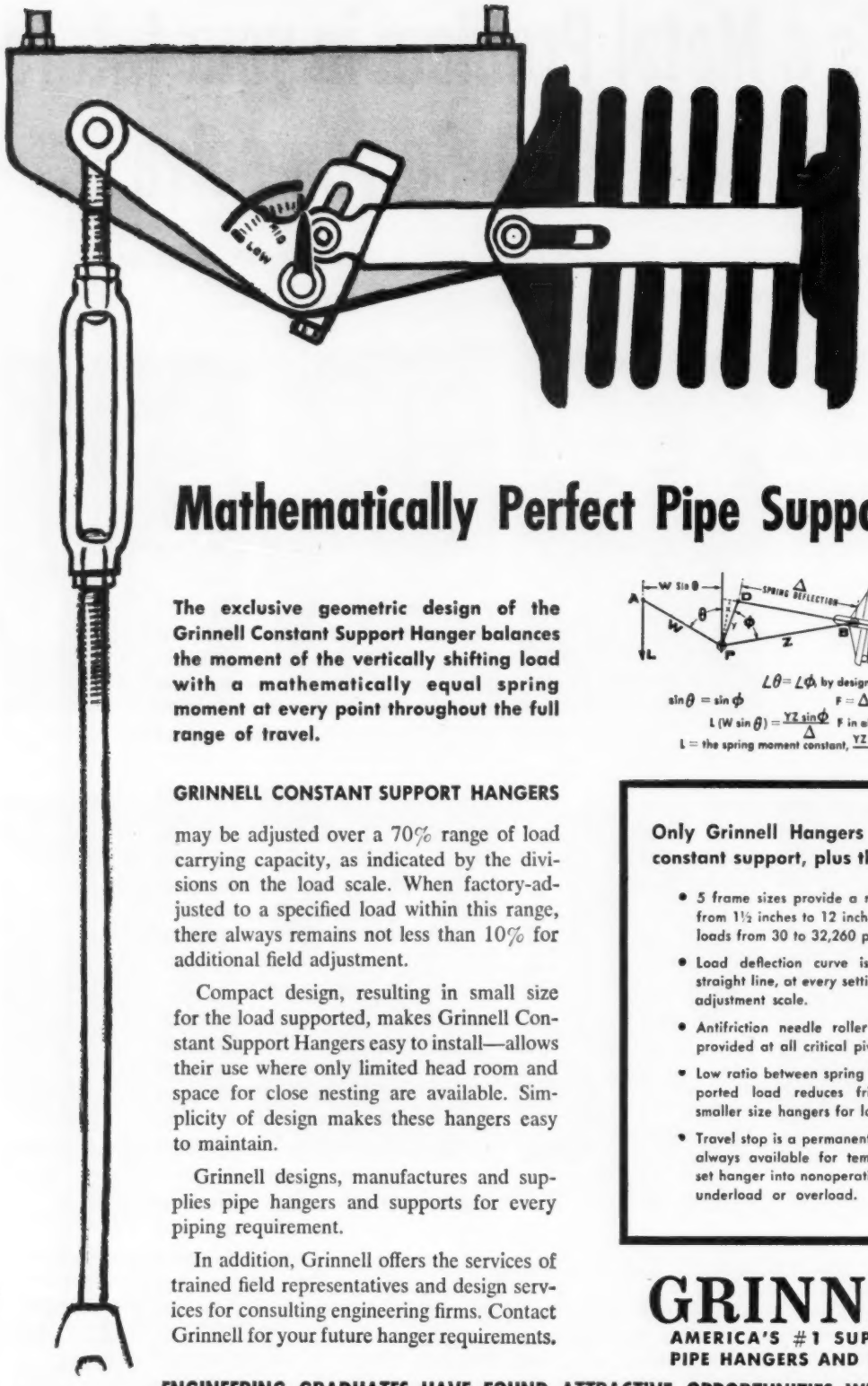

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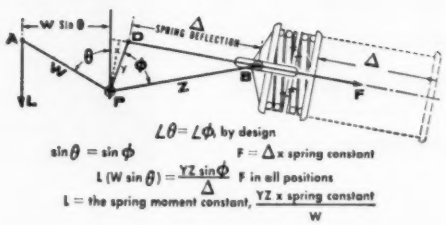

$\angle\theta = \angle\phi$ by design

$\sin\theta = \sin\phi$ $\quad F = \Delta \times$ spring constant

$L(W \sin\theta) = \frac{YZ \sin\phi}{\Delta}$ F in all positions

L = the spring moment constant, $\frac{YZ \times \text{spring constant}}{W}$

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may be adjusted over a 70% range of load carrying capacity, as indicated by the divisions on the load scale. When factory-adjusted to a specified load within this range, there always remains not less than 10% for additional field adjustment.

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FIFTY YEARS AGO

(Continued from Page 37)

in school or even entrance examinations they cribbed, but they should be made to understand they are here to work fairly and squarely. It may have to be strictly enforced at first, but when they catch the spirit it will work by itself. By Senior year they will be glad that they have been in a college where there is an honor system that works.

If the Juniors vote to have it removed it will be one of the greatest losses that the college has had for some time. It will be equivalent to acknowledging that they are a bunch of men not capable of being trusted and without the spirit and back-bone that makes honest men. One of the greatest steps forward will be taken away and the College will sink back into its old shiftless ways. It is a thing to think about and think hard. All this year our Honor system has been a thing to boast about, and if it goes, the men who are responsible for the action and who are afraid to live up to its rules have no right to call themselves Cornellians.—(Cornell Civil Engineer—*April, 1908.*)

An innovation of great importance both to the College of Civil Engineering and to the whole University has been proposed by several of the professors in Civil Engineering. The plan is to purchase or rent a building to be used as a general eating place, a club house, and as far as possible as a dormitory, by the students in Civil Engineering.

An option has been secured on the building on Dryden Road known as the Court Inn. This would provide a large dining room, several club rooms and a number of sleeping rooms. While this building is far from ideal in all respects, it would at least give us a good start toward something better.

A meeting of the Association was held during the week before Christmas at which the plan was heartily endorsed by the students. Anyone who has spent four years in an Ithaca boarding house will readily appreciate their enthusiasm in the matter. Some of the fraternities have proposed to let their freshmen eat at the commons also, in order to get better acquainted with their class-mates. As a means of promoting better acquaintance and fostering college spirit, we believe the advantages of the proposed scheme will appeal to everyone.

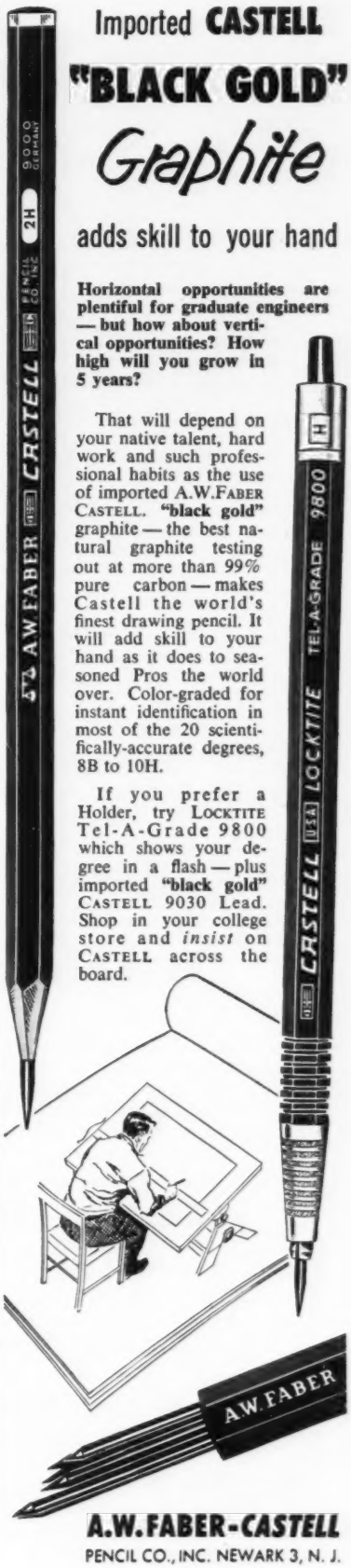
The need of suitable rooms for the meetings of the Association has long been felt. It is almost certain that the number of men who turn out would be two or three times as great if the meetings were held in a building of our own.

Besides its value to undergraduates, the alumni will readily appreciate the difference there will be if, when on a visit to Ithaca they can put up at a club house which has so many bonds of acquaintanceship and friendship, and which they have a right to call a home. A representative of the undergraduates is to be present at the annual banquet of the Cornell Society of Civil Engineers of New York on January twenty-second. He will speak about the present condition of affairs in Ithaca, and especially about the plans for the new club house.

The financial plan is now being worked out by the committee. The alumni will probably be called upon for help in financing the scheme.—(Cornell Civil Engineer—*January, 1909*)

The quartermaster woke the men at 6:30 A.M. and breakfast was served from 6:45 to 7:00. All parties (surveying) were expected to leave camp by 7:30 A.M. One half hour was allowed for lunch and the parties stopped work in the afternoon in time to reach camp by 5:30 P.M. The instruments were then put away and the captain of each party wrote his daily report and turned it in to the computer. Dinner was served from 6 to 7 P.M., and voluntary parties reported for night astronomy. The remainder of the men either reported for computations or amused themselves in some other manner.

A majority of the men obtained permission to go to Ithaca over Saturday night and Sundays; they also attended the lawn fetes and socials held in the surrounding country, thus preventing the work from becoming monotonous. (Excerpt from "Report of the Chief Engineer of the 1908 Junior Survey"—(Cornell Civil Engineer—*October, 1908*)



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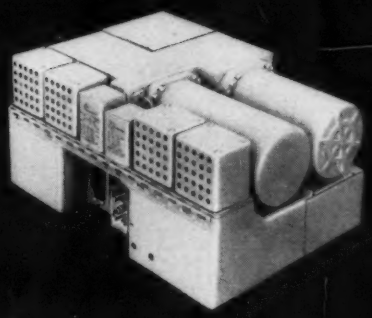

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STRESS *and* STRAIN...

Don't ever trust a coed.
You'll be sorry if you do.
Don't listen to their double talk
That's my advice to you.
They come to this here college
Just to get themselves a man;
With one for every four of us
It's simple how they can.
As Sophs they've good intentions,
They're satisfied with one;
But time instills a greedy lust,
They add two more for fun.
It's one against two others,
Which starts a "battle-royal."
They rake in all the profits
As a pirate does his spoil.
Wake up you merry gentlemen,
And get this through your dome
If you must have a date at all
Take out that girl at home.

• • •

If all the coeds in the world who didn't neck gathered in one room, what would we do with her?

• • •

"You missed my class last time, didn't you?"

"No sir, not a bit."

• • •

Him: "May I take you home? I like to take experienced girls home."

Her: "I'm not experienced."

Him: "You're not home yet either."

• • •

Senior Engineer: We're coming to a tunnel. Are you afraid?

Co-ed: Not if you take that cigar out of your mouth.

• • •

A salesman stranded in a small village asked one of the natives if there was a movie in town.

"Nope," was the reply.

"Any bowling alleys in town?"

"Nope."

"What form of amusement do you have?" asked the exasperated salesman.

"Wal, come down to the drug store," said the old man. "Thar's a freshman home from college."

"Let's see if we can locate the cause of your neurosis," said the psychoanalyst to the harassed soul before him. "What kind of work do you do?"

"I sort oranges," was the reply.

"I don't think I understand," the doctor admitted. "Please elaborate."

"All day," the patient explained, "oranges keep pouring down a chute. I stand at the bottom and sort them. Big oranges in one crate, medium in another and little ones in another. See?"

"It sounds easy to me," said the doctor.

"Easy!" cried the patient. "Don't you realize it means decisions! decisions! all day long!"

• • •

Two young collegians were parked along a country lane. The moon was shining beautifully.

She: "You remind me of Don Juan."

He: "What do you know about him? He's dead."

She: "Yeah, I know."

• • •

The Dean of the college looked up questioningly at the man who had entered his office, and now stood regarding him gravely. "And what can I do for you sir?" he inquired.

"I don't suppose you remember me," the visitor began, "I'm Pollard of the class of '30. The year I left school, I was very hard up and you lent me ten dollars. And I told you that when I made good I would come back and remind you of it, and pay you back—"

"Go on," said the dean, beaming at him.

"So here I am. You don't happen to have another ten-spot on you, do you?"

• • •

Girl: "I nearly fainted when the fellow I was out with last night asked me for a kiss.

Aggie: "Baby, you're going to die when you hear what I have to say."

A man never knows if he likes bathing beauties until he's bathed one.

• • •

Kid Brother: "Give me a nickel or I'll tell dad that you held hands with my sister."

E.E.: "Here you are."

K.B.: "Give me a quarter or I'll tell him you kissed her."

E.E.: "Here, pest."

K.B.: "Now give me five dollars!"

• • •

A smart girl doesn't have to watch the speedometer to know what her date is driving at.

• • •

Physics prof.: "If in going down this incline, I gain four feet per second, what will be the condition after 25 seconds?"

Smart soph.: "You'll be a centipede."

• • •

He was a rather undersized freshman at his first college dance, but despite his smallness and bashfulness he was sure of himself in his own way. He walked over to a beautiful and over-sophisticated girl and said, "Pardon me, Miss, but may I have this dance?"

She looked down at his small size and lack of fraternity pin and said, "I'm sorry, but I never dance with a child–"

The freshman bowed deeply and said, "Oh, I'm sorry, I didn't know your condition."

• • •

"Ethics," the man told his son, "is vital to everyday living. For example, today an old friend paid me back a loan with a new hundred-dollar bill. As he was leaving I discovered he'd given me two bills stuck together. Immediately a question of ethics arose: Should I tell your mother?"

• • •

E.E.: "She's a nicely reared girl, isn't she?"

M.E.: "Not bad from the front either."

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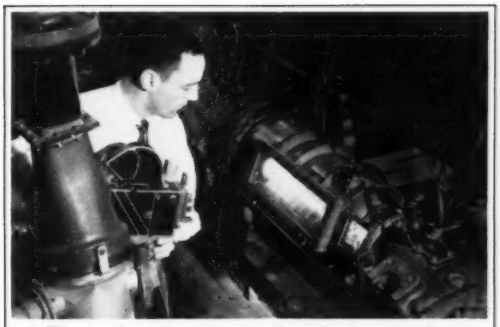

The motion picture camera is seeing into a turbo-jet combustion chamber operating on a new fuel.

With photography as a tool, the N.A.C.A. Lewis Flight Propulsion Laboratory studies jet engine combustion chambers, and compounds that can result in new high-energy jet fuels

How much faster and farther our aircraft and missiles can go seems now to depend on developing new high-energy fuels. This is a job of the Lewis Laboratory of the National Advisory Committee for Aeronautics.

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One of a series

Interview with General Electric's Frank T. Lewis Mgr., Manufacturing Personnel Development

The Next Four Years: Your Most Important

The United States is now doubling its use of electrical energy every eight years. In order to maintain its position as the leading manufacturer in this fast-growing electrical industry, General Electric is vitally interested in the development of young engineers. Here, Mr. Lewis answers some questions concerning your personal development.

Q. Mr. Lewis, do you think, on entering industry, it's best to specialize immediately, or get broad experience first?

A. Let me give you somewhat of a double-barreled answer. We at General Electric think it's best to get broad experience in a specialized field. By that, I mean our training programs allow you to select the special kind of work which meets your interests—manufacturing, engineering, or technical marketing—and then rotate assignments to give you broad experience within that area.

Q. Are training assignments of a predetermined length and type or does the individual have some influence in determining them?

A. Training programs, by virtue of being programs, have outlined assignments but still provide real opportunities for self-development. We try our best to tailor assignments to the individual's desires and demonstrated abilities.

Q. Do you mean, then, that I could just stay on a job if I like it?

A. That's right. Our programs are both to train you and help you find your place. If you find it somewhere along the way, to your satisfaction and ours, fine.

Q. What types of study courses are included in the training programs and when are the courses taken?

A. Each of our programs has graduate-level courses conducted by experienced G-E engineers. These courses supplement your college training and tie it in with required industrial techniques. Some are taken on Company time, some on your own.

Q. What kind of help do you offer employees in getting graduate schooling?

A. G.E.'s two principal programs of graduate study aid are the Honors Program and the Tuition Refund Program. If accepted on the Honors Program you can obtain a master's degree, tuition free, in 18 months while earning up to 75% of full-time salary. The Tuition Refund Program offers you up to 100% refund of tuition and related fees when you complete graduate courses approved by your department manager. These courses are taken outside normal working hours and must be related to your field of work.

Q. What are the benefits of joining a company first, then going into military service if necessary.

A. We work it this way. If you are hired and are only with the Company a week before reporting to military service, you are considered to be performing continuous service while you are away and you will have your job when you return. In determining your starting salary again, due consideration is given experience you've gained and changes in salary structure made in your absence. In addition, you accrue pension and paid-vacation rights.

Q. Do you advise getting a professional engineer's license? What's it worth to me?

A. There are only a few cases where a license is required at G.E., but we certainly encourage all engineers to strive for one. At present, nearly a quarter of our engineers are licensed and the percentage is constantly increasing. What's it worth? A license gives you professional status and the recognition and prestige that go with it. You may find, in years to come, that a license will be required in more and more instances. Now, while your studies are fresh in your mind, is the best time to undertake the requirements.

Your next four years *are* most important. During that period you'll undoubtedly make your important career decisions, select and complete training programs to supplement your academic training, and pursue graduate schooling, if you choose. These are the years for personal development — for shaping yourself to the needs of the future. If you have questions still unanswered, write to me at Section 959-6, General Electric Co., Schenectady 5, N. Y.

LOOK FOR other interviews discussing: • Salary • Advancement in Large Companies • Qualities We Look for in Young Engineers.

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